



# **CALIPSO Status and Results**

***Dave Winker  
NASA LaRC***

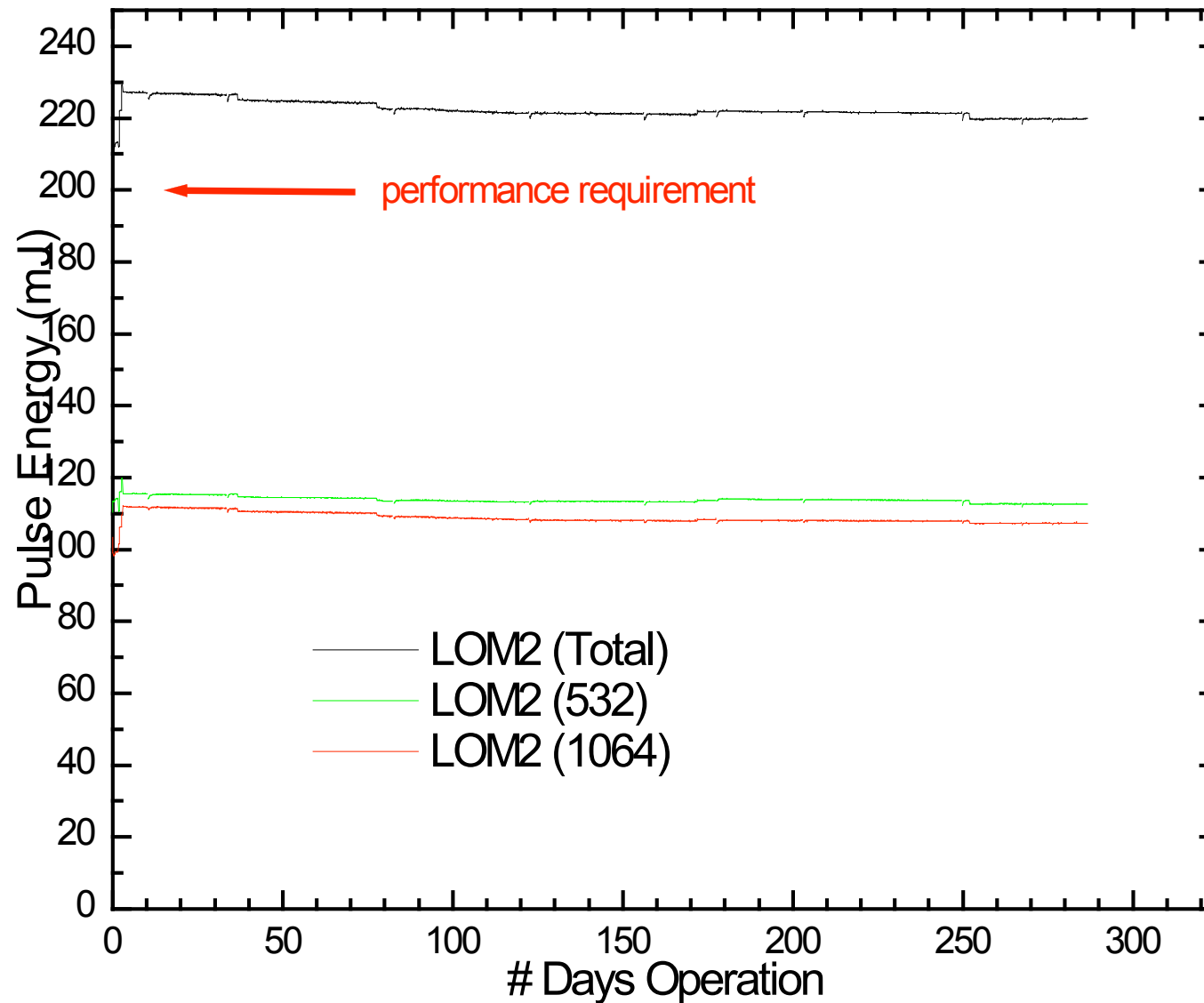
***With contributions from Bob Holz, Yong Hu, Jay Mace***



## O-orbit LOM-2 pulse energy (to 17 April)



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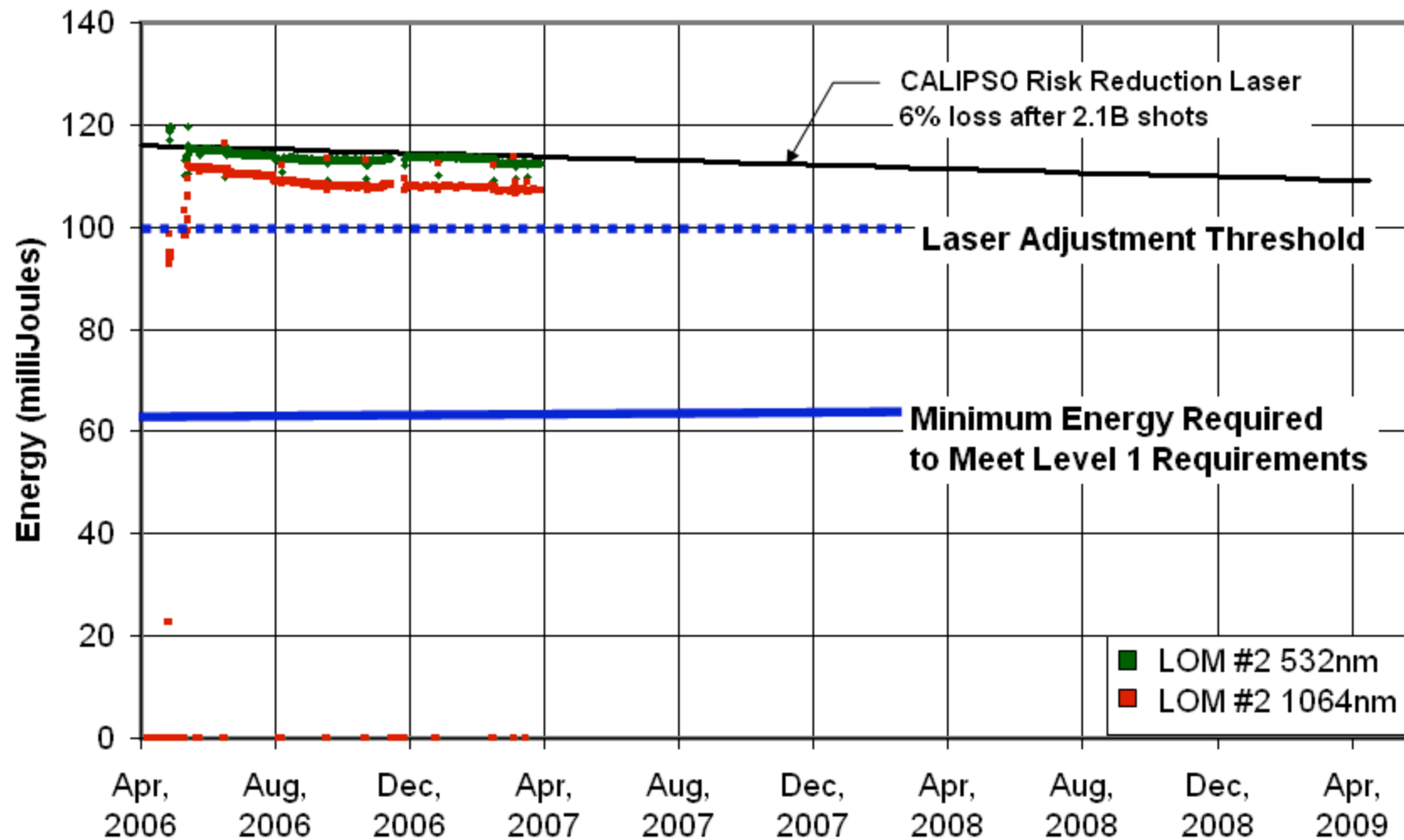




# LOM-2 Performance vs. RRL



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April 20, 2007

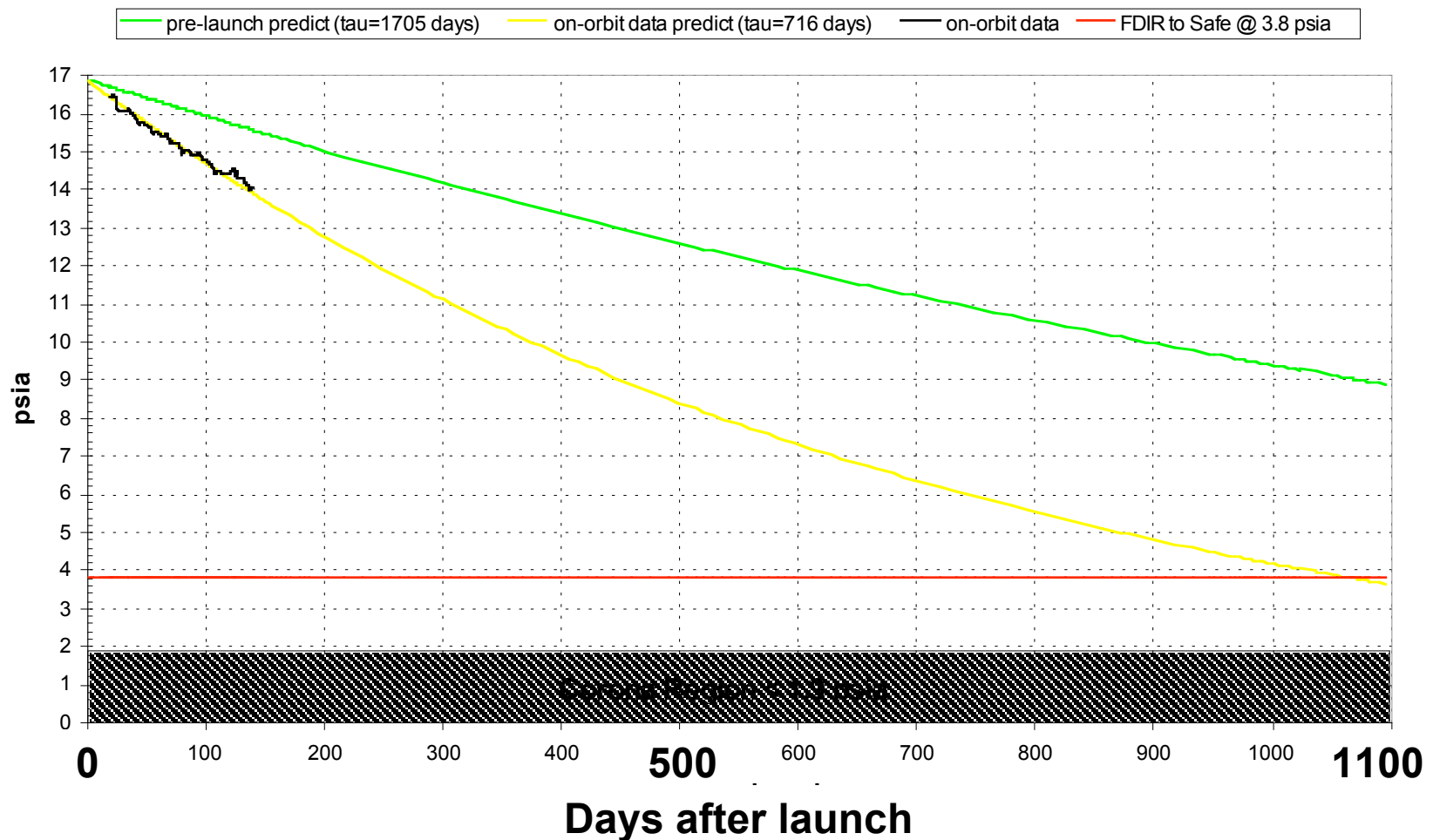


# LOM-2 Canister Pressure



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**LOM-2 Canister Pressure continues to follow post launch trend, projected 3-year life before hitting corona threshold**





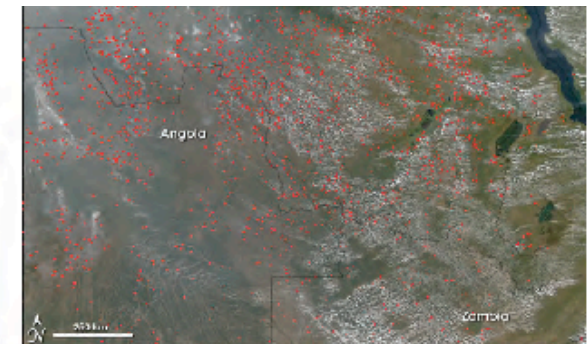
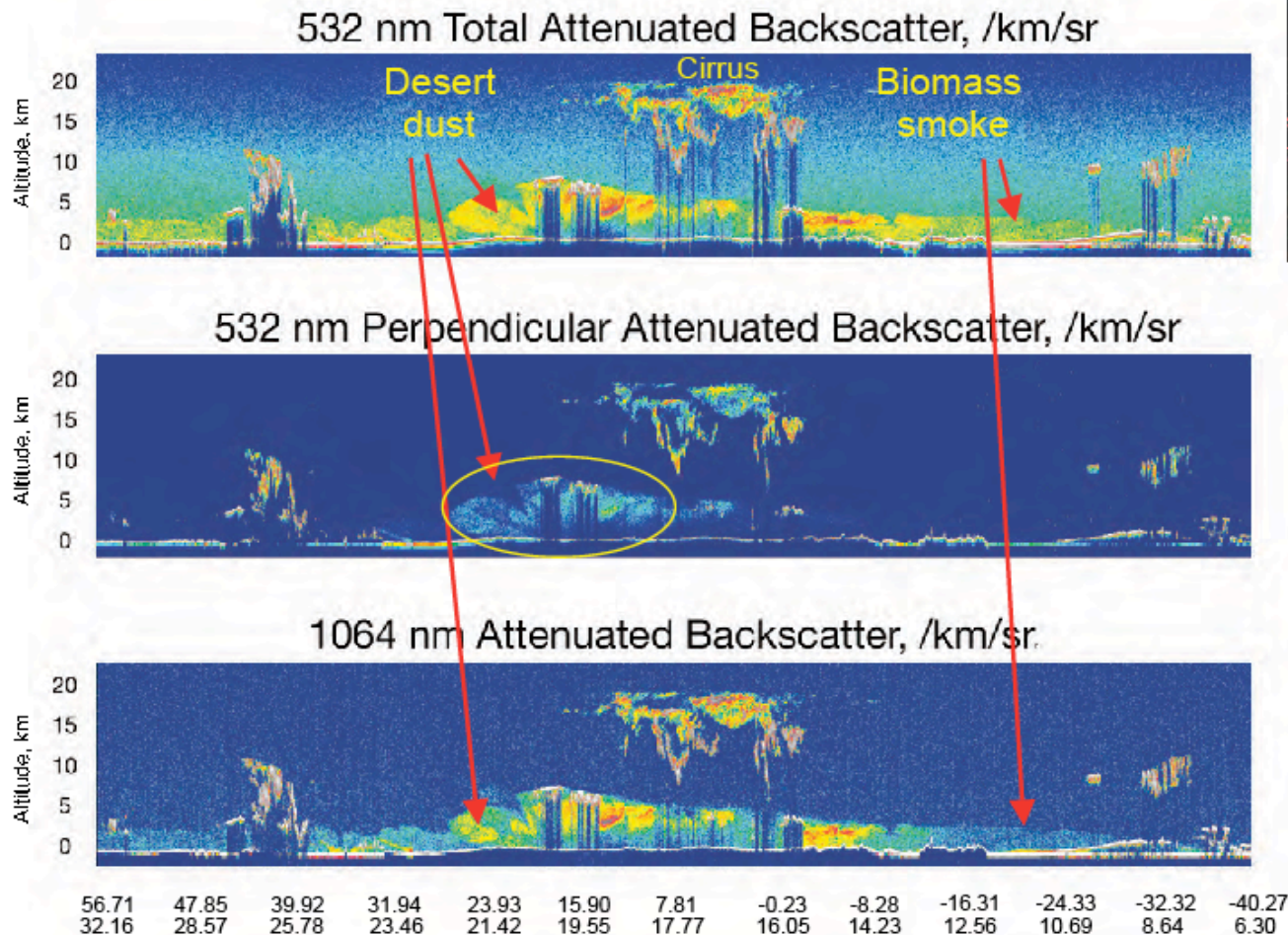


# CALIPSO First Light Observations (all 3 channels)

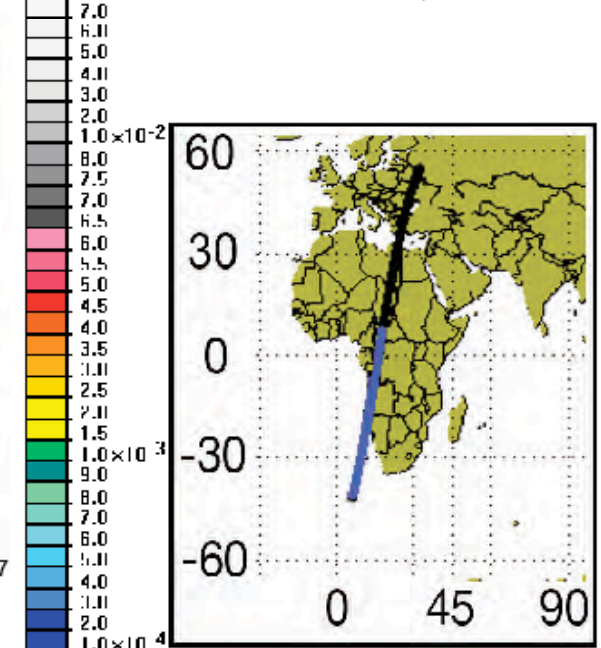


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June 9, 2006



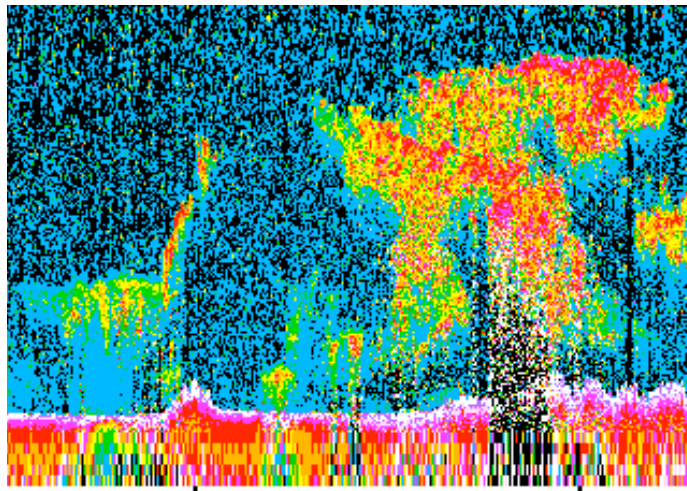
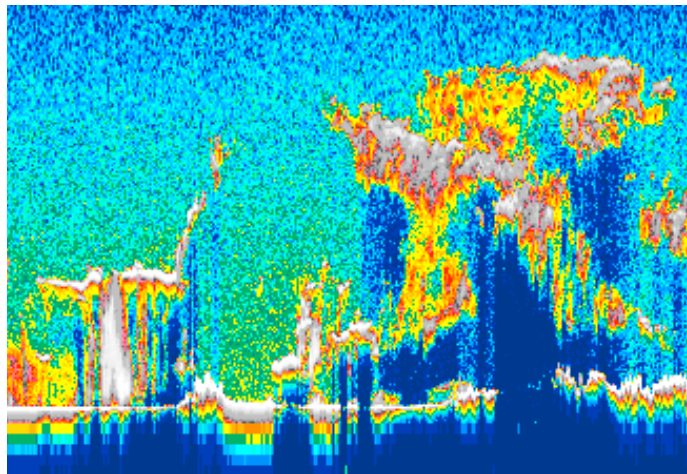
Fire locations in southern Africa from MODIS, 6/10/06





## Arctic clouds

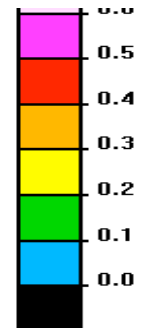
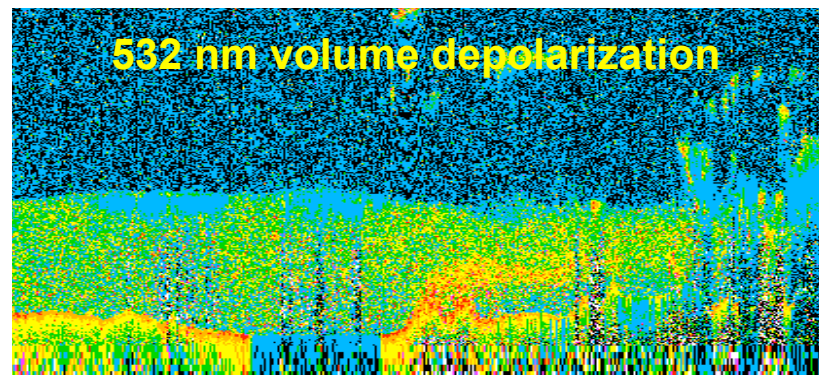
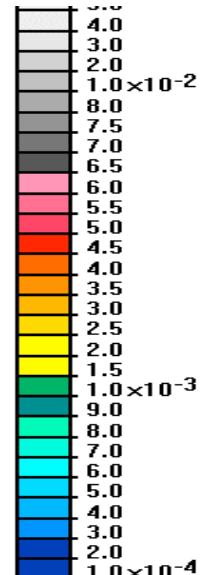
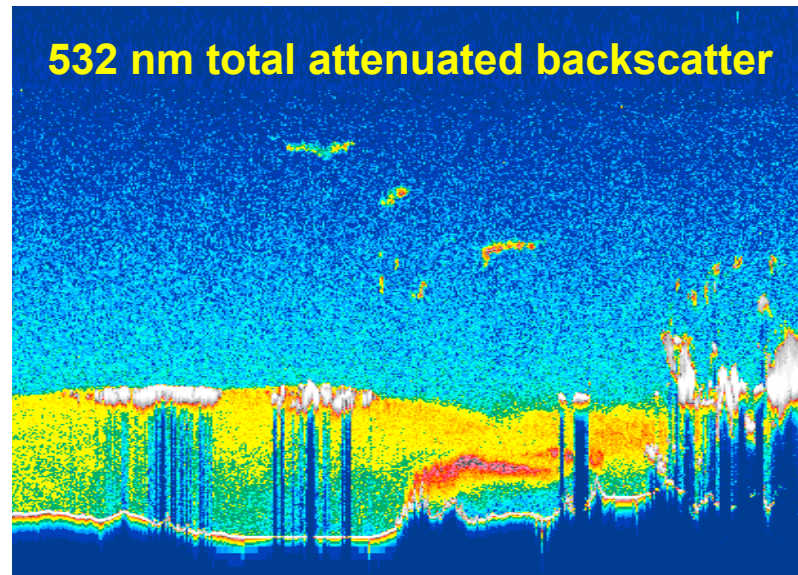
identification of water, and both random and oriented ice crystals



75.38  
110.49

68.26  
97.64

## Sahara dust with embedded water clouds



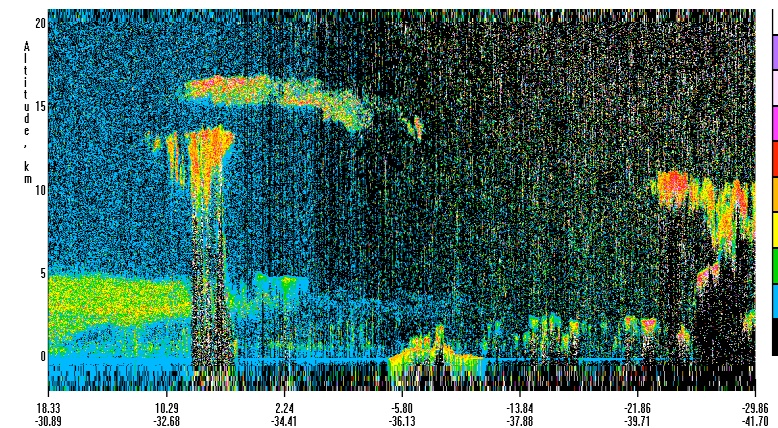
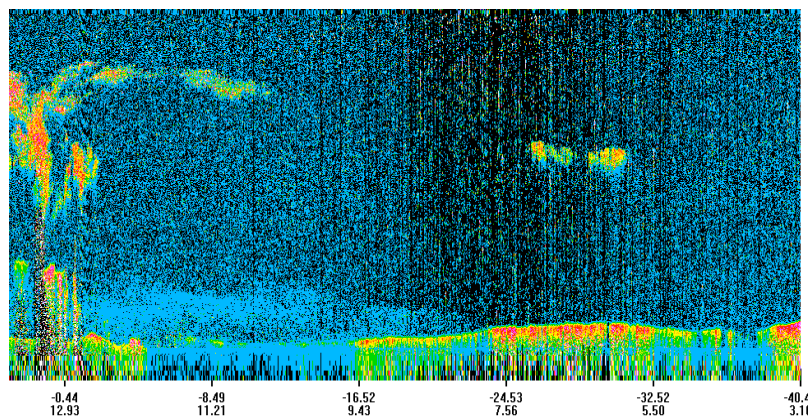
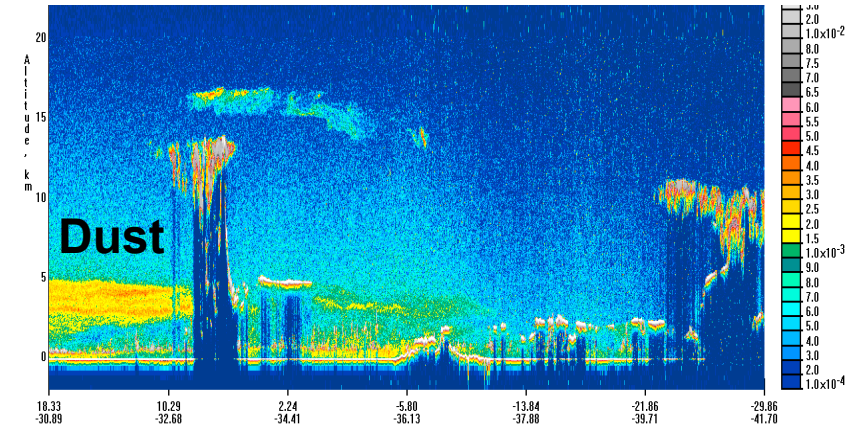
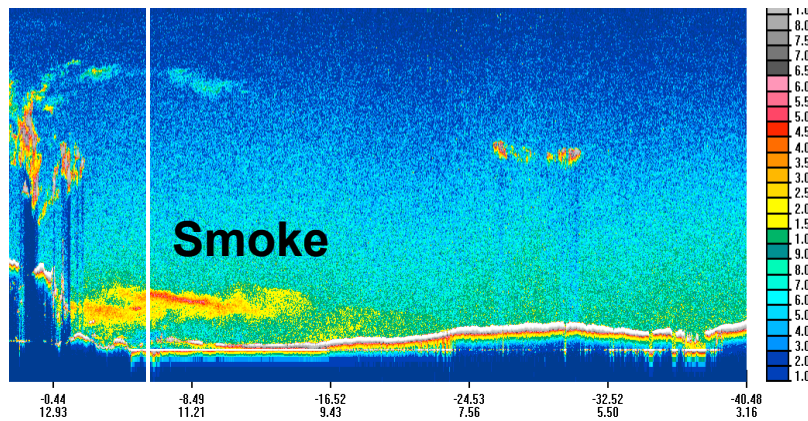
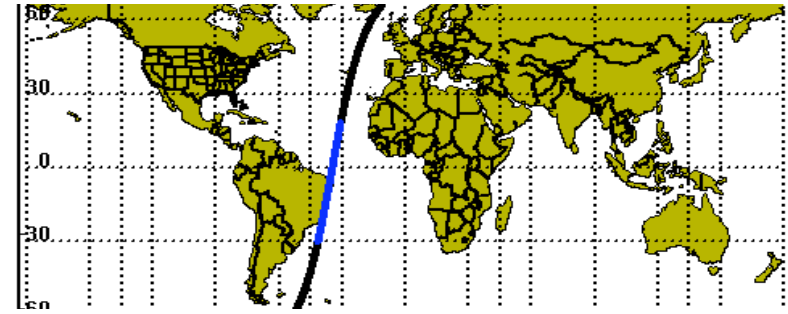
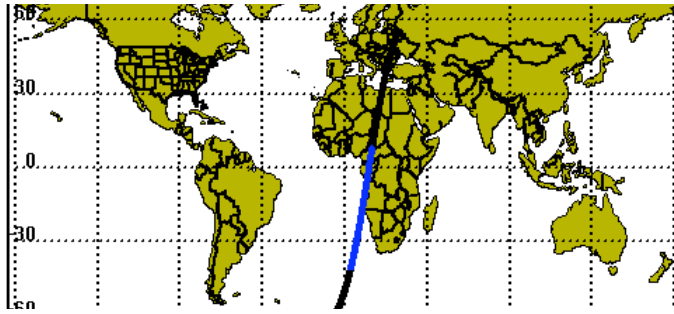
23.67  
39.90

15.64  
38.04

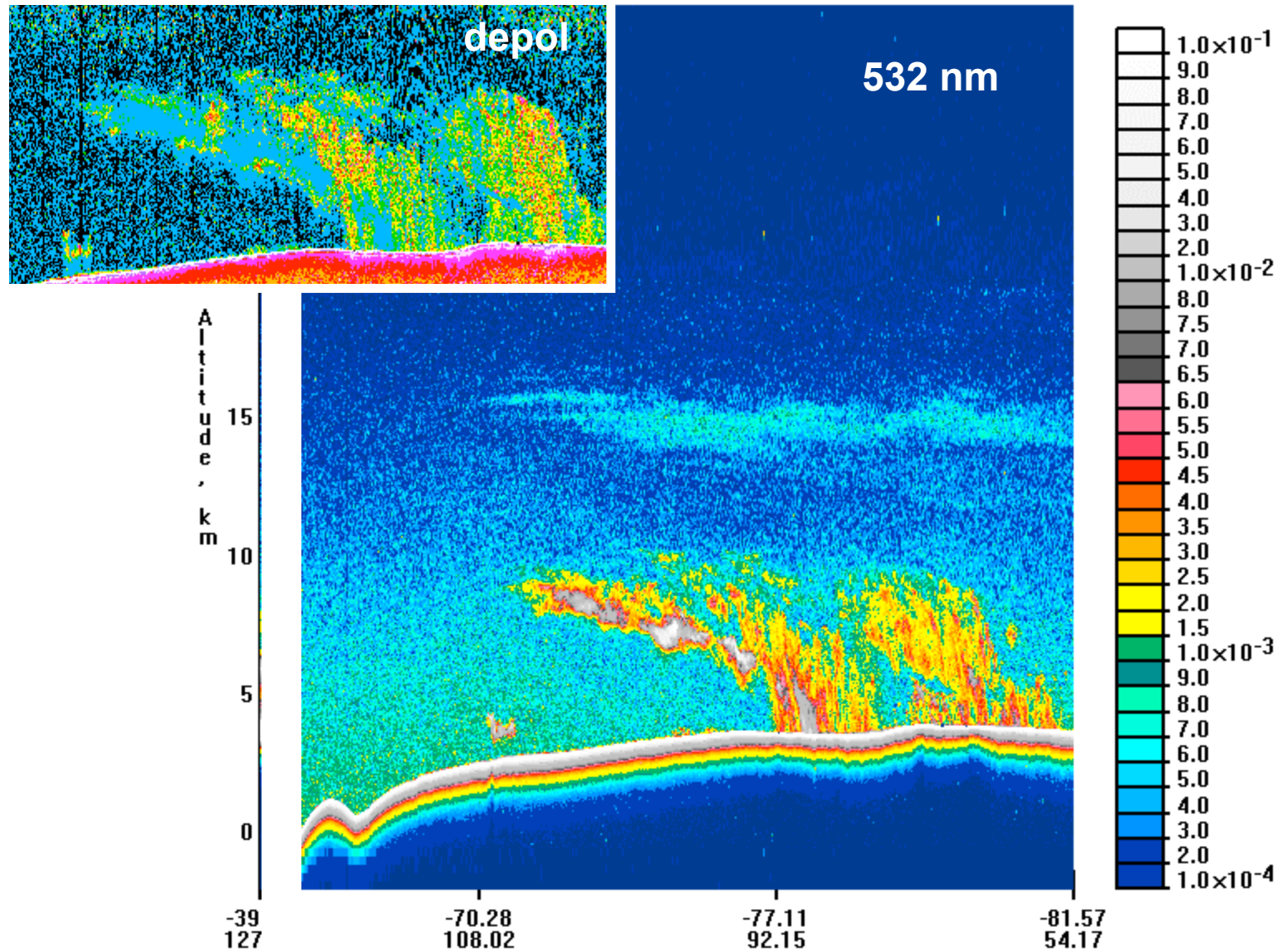
7.60  
36.28



# Type Identification: Smoke vs. Dust



# Antarctic Cloud (8 July 2006)





# CALIPSO Data Products



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## Level 1 (geolocated and calibrated)

- DP1.1 - profiles of **attenuated lidar backscatter (532, 532<sub>⊥</sub>, 1064)\***
- DP 1.2 – IR **radiances (8.65, 10.6, 12.05 μm)**
- DP 1.3 – Visible **radiances (650 nm)** (WFC)

## Level 2

- DP 2.1A – **Cloud/Aerosol layer product**
  - **layer base and top heights, layer-integrated properties**
- DP 2.1B – Aerosol profile product
  - backscatter, extinction, depolarization profiles
- DP 2.1C – Cloud profile product
  - backscatter, extinction, depolarization, ice/water content profiles
- DP2.1D – **Vertical mask**
  - cloud/aerosol locations
- Also: products from IIR + CALIOP + WFC: cloud  $T_B(\lambda)$ , emissivity,  $r_e$

## Level 3

- Summary statistics on a global grid

**\* included in initial data release**





# Data Archive Status



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- **In-line version upgrades**
  - no reprocessing until V2.0 (Nov 2007)
- **V1.10 – 8 Dec 2006**
  - Initial, “provisional”, data release
- **V1.11 – 6 Jan 2007**
  - bug in Level 1 code fixed, no impact to data products
- **V1.2 - not released yet, pending QA checks**
  - transitioned from GEOS-4 to GEOS-5 on ~1 April
- **ASDC archive activity**
  - Data volume produced – 11.7 TB
  - # registered users - 248
  - Data volume distributed - 29 TB



# Summary of CALIOP Data Quality



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- **Known calibration issues**
  - **532 night:**
    - > **uncorrected stratospheric aerosol**
    - > **GEOS-4 → GOES-5 transition**
  - **532 day:**
    - > **Observed instrument behavior different from assumptions**
  - **1064 issues:**
    - > **Cirrus backscatter more complicated than expected**
    - > **Any 532 calibration errors propagate into 1064**
- **Level 2 products**
  - **Little validation done yet, but layer detection and heights look good (largely independent of calibration)**
  - **Cloud/aerosol discrimination – largely OK, but some systematic identification errors**

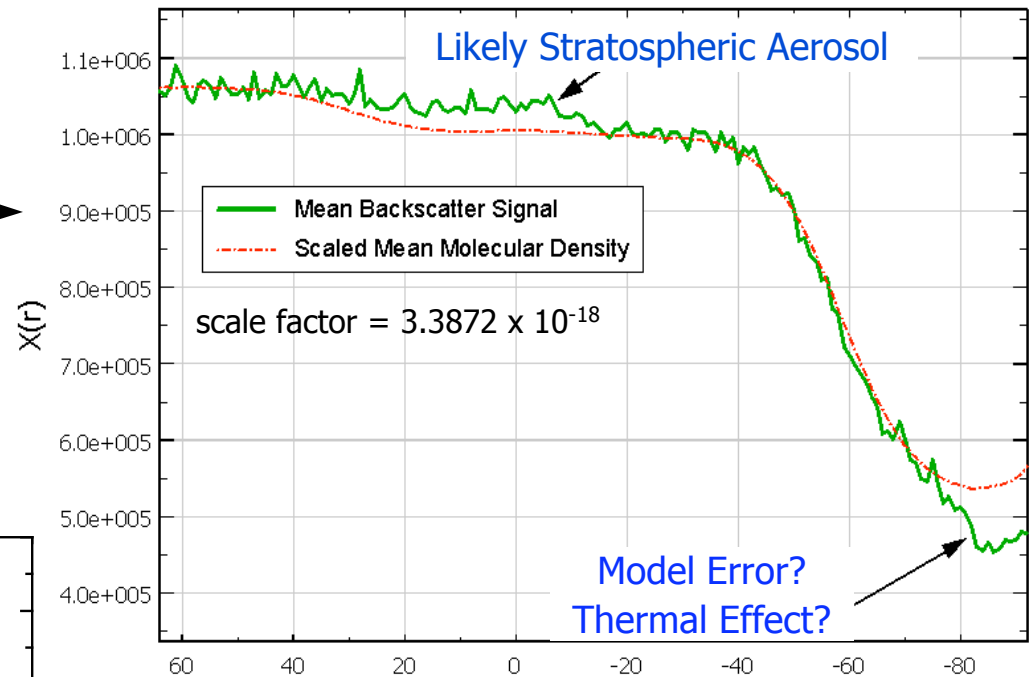
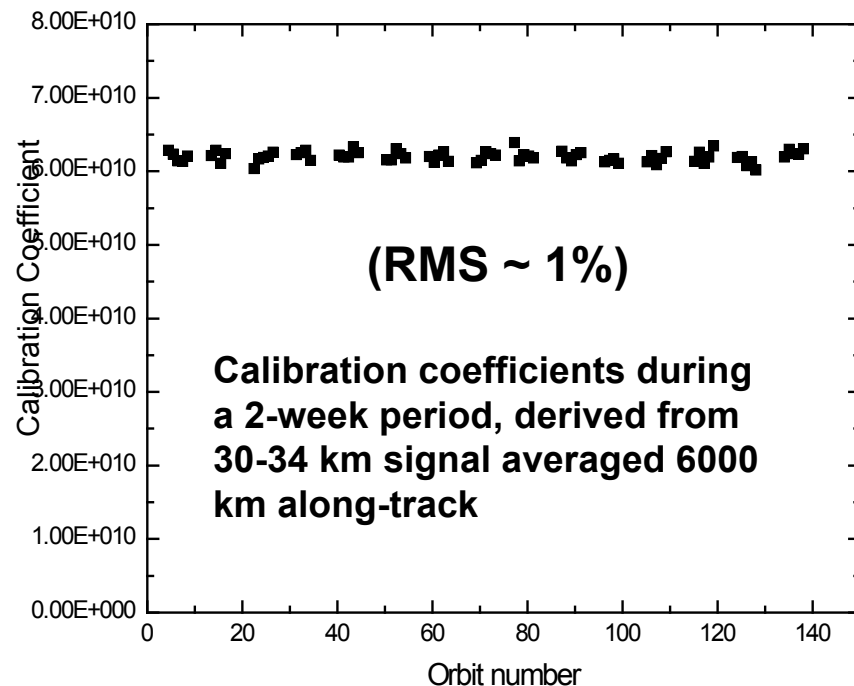


# Status: 532-parallel calibration



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532-parallel channel calibrated  
by normalization of high-altitude  
returns (30-34 km) →  
to molecular density (from  
GMAO)



**Averaging over large intervals  
( $> \frac{1}{2}$  orbit) continues to  
improve SNR by  $1/N^{1/2}$**

**RMS variation of calibration  
coefficients slightly larger than  
expected from signal noise alone**

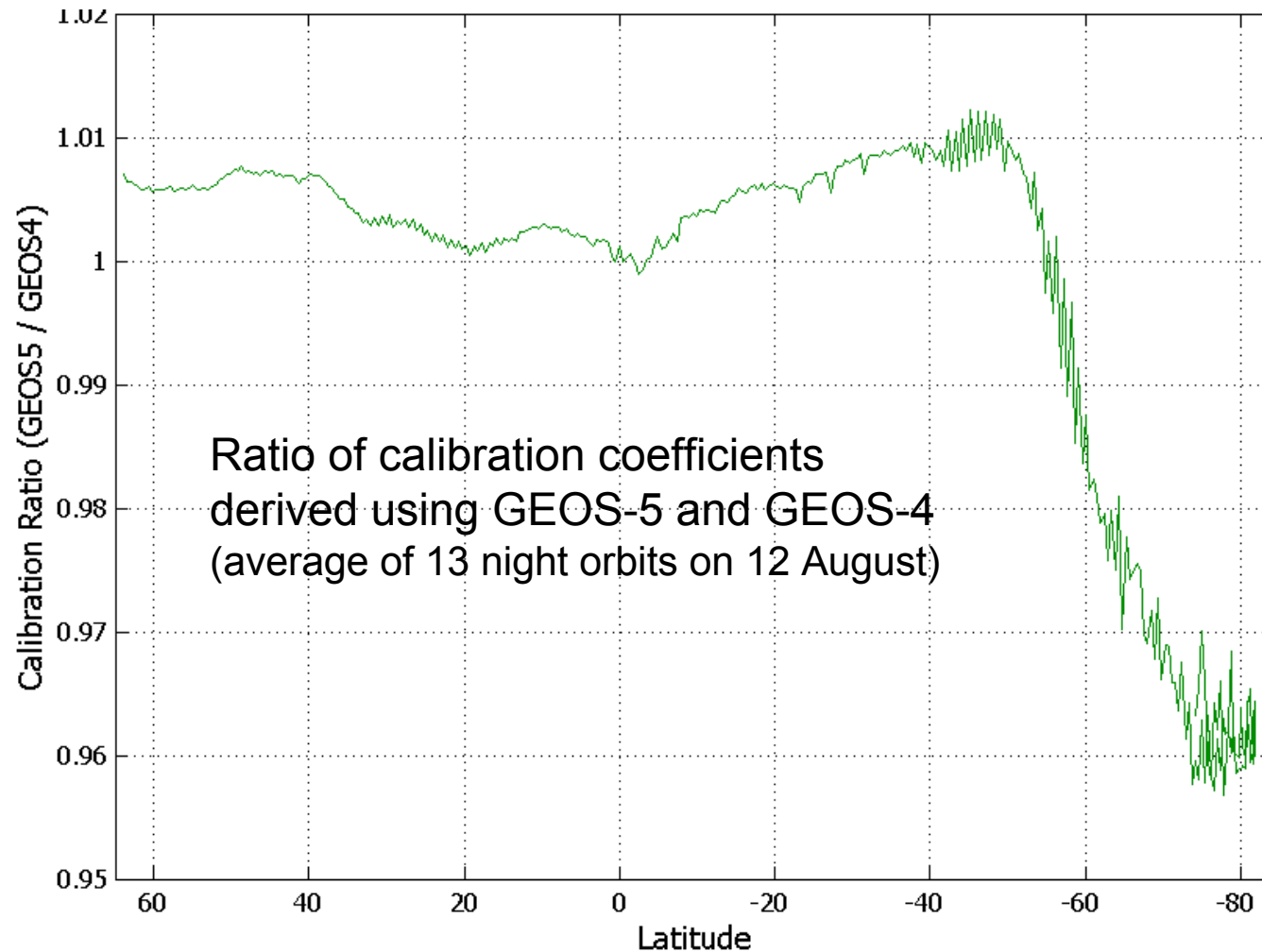




# Geos-4 to Geos-5 transition affects calibration



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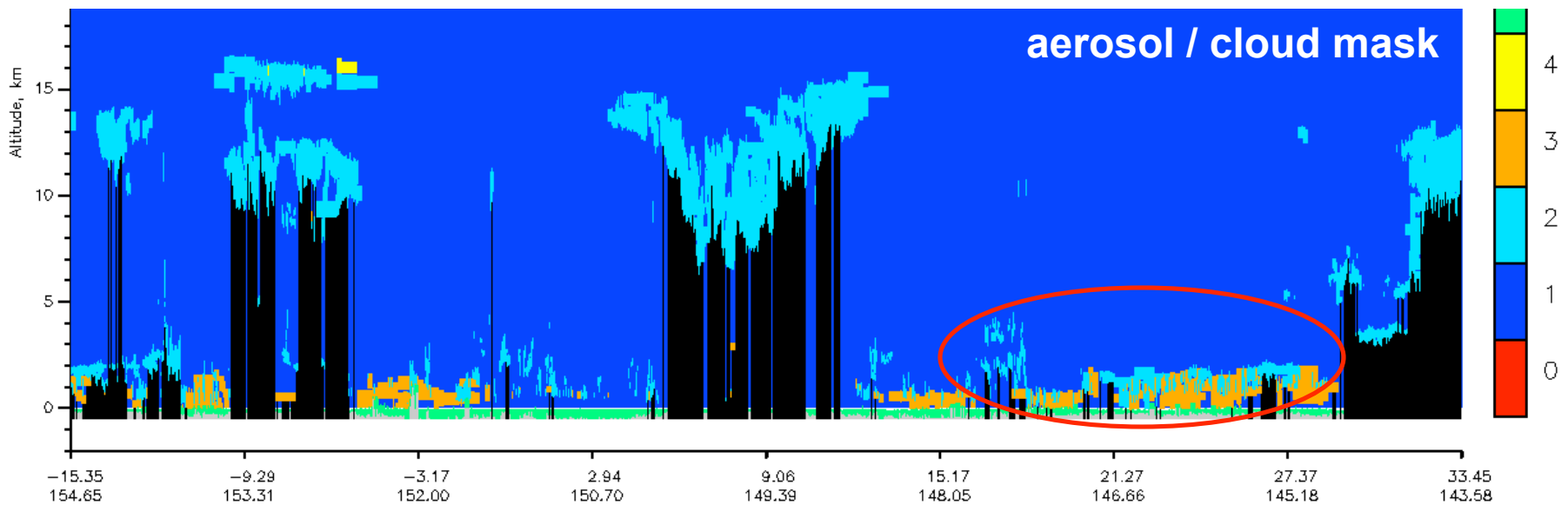
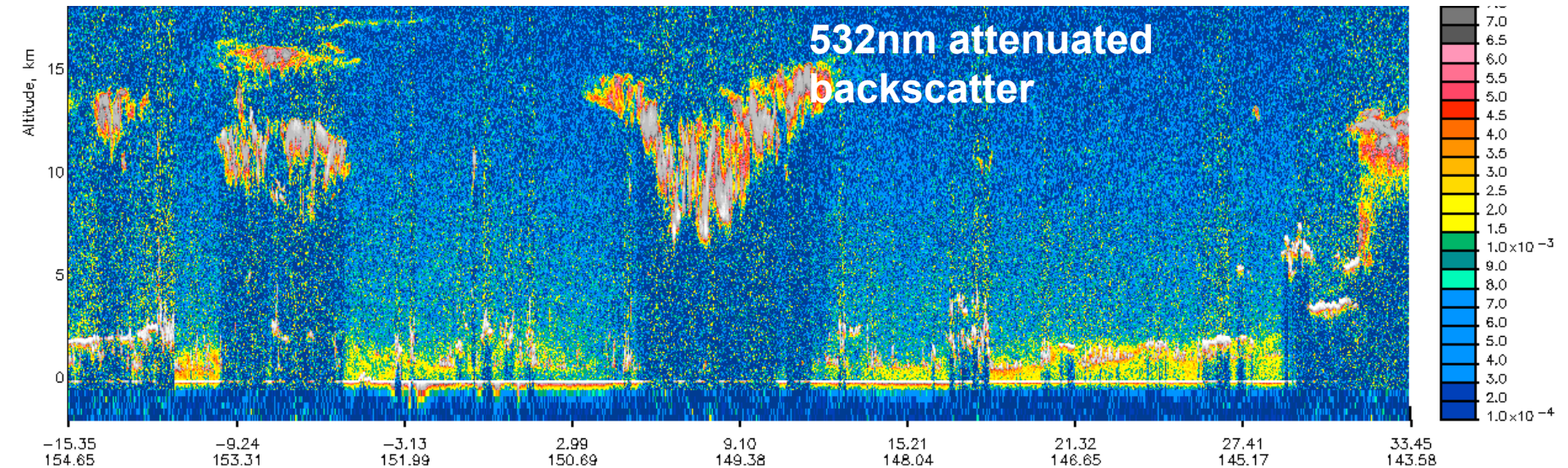




# Cloud-Aerosol Discrimination (Western Pacific, day)



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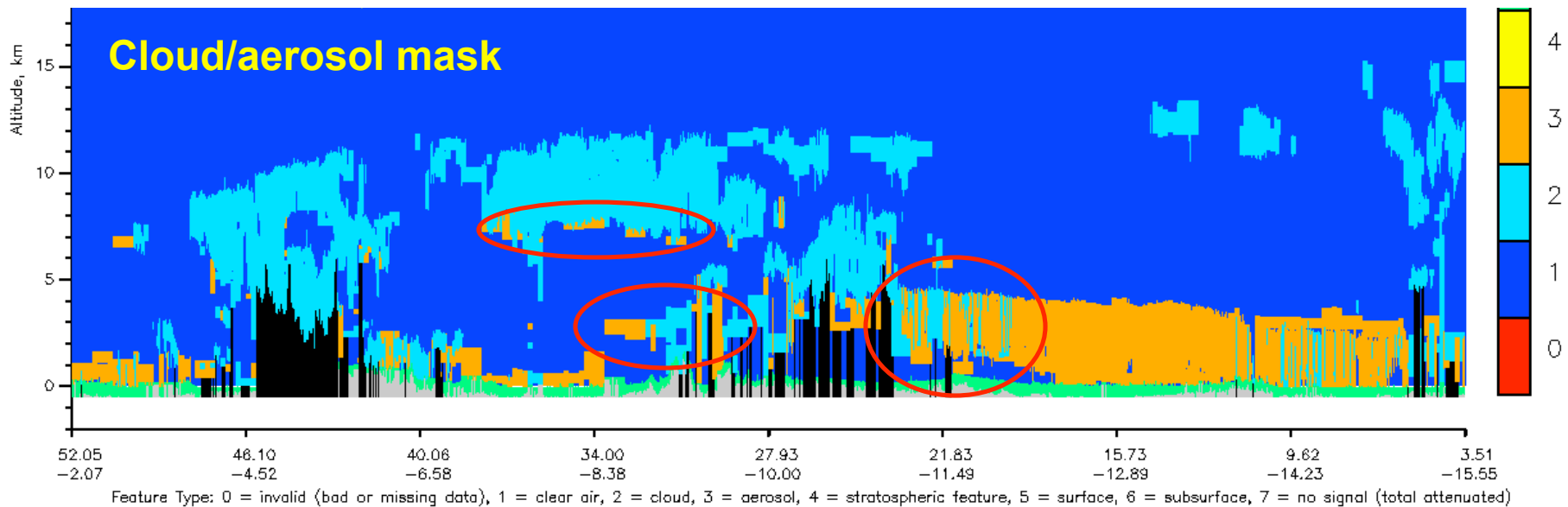
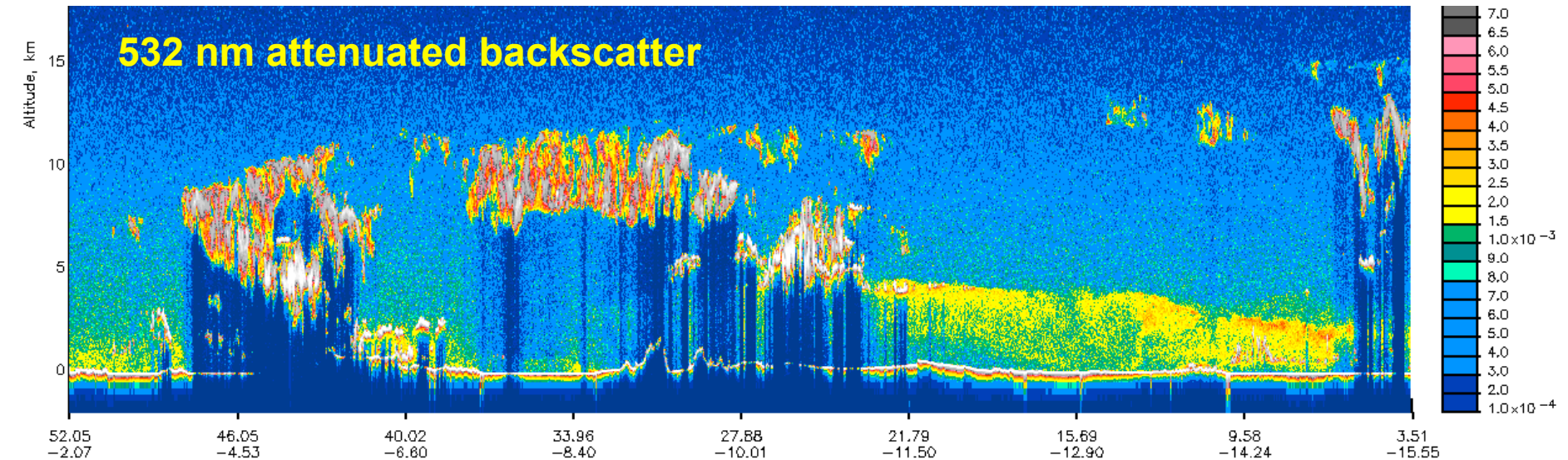
Feature Type: 0 = invalid (bad or missing data), 1 = clear air, 2 = cloud, 3 = aerosol, 4 = stratospheric feature, 5 = surface, 6 = subsurface, 7 = no signal (total attenuated)



# Cloud-Aerosol Discrimination (West Africa – night)



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# Validation Status

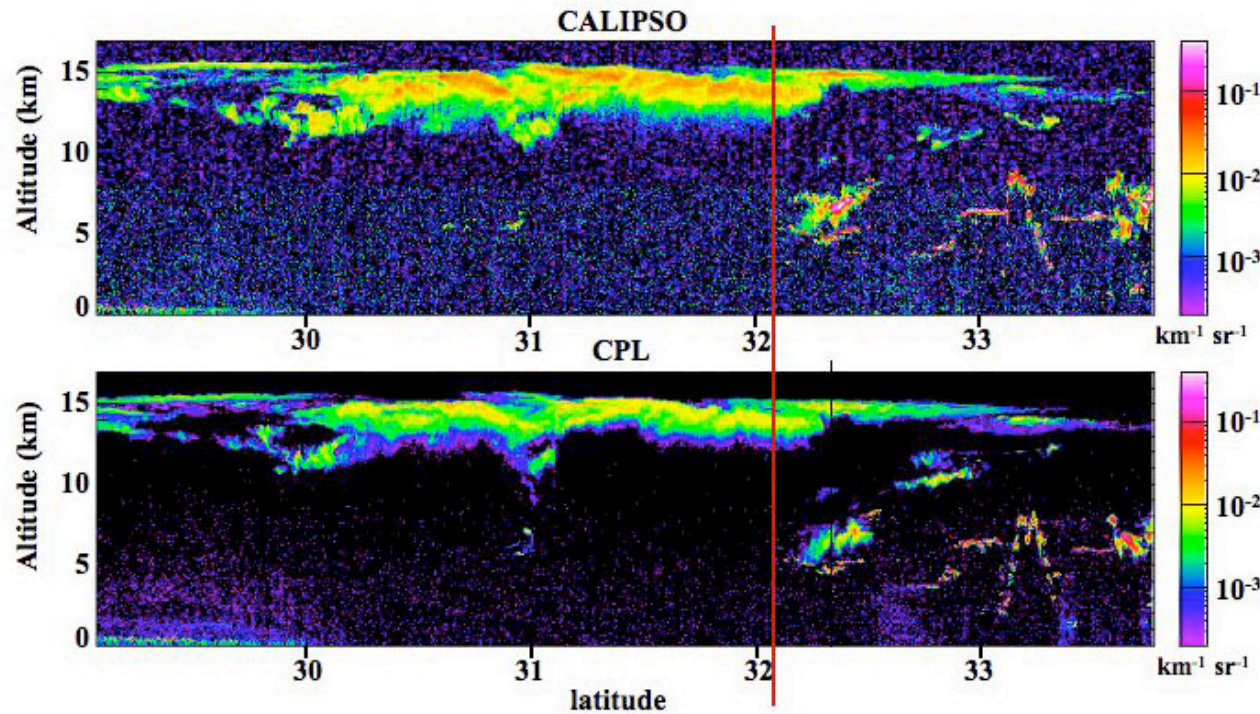


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- **532 nm calibration**
  - Northern hemisphere *night* looks good (other than strat. aer.)
  - Working to improve daytime and correct for stratospheric aerosol
  - Need validation comparisons in S hemisphere
- **Depolarization calibration**
  - Looks good
- **1064 nm calibration**
  - Any errors at 532 nm propagate into 1064 calibration - validation just beginning
  - Need comparisons with airborne/groundbased systems with well-calibrated 1064 channels
  - Also looking into alternate calibration techniques
- **Layer height**
  - Completing initial quantitative study – looks good

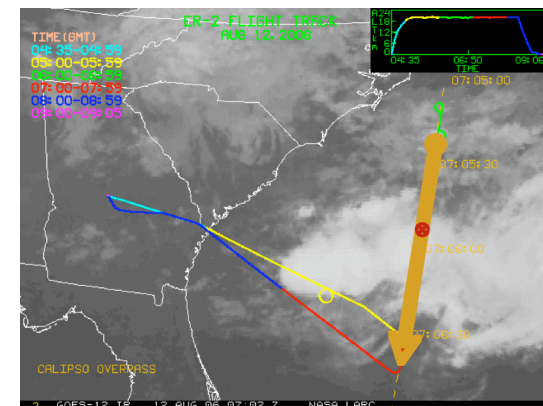
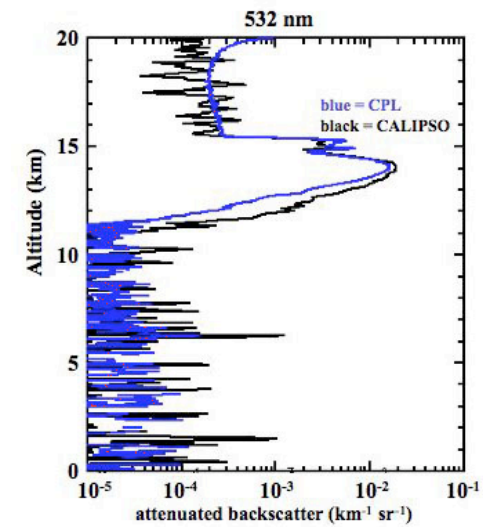


## 532 nm Calibrated Attenuated Backscatter



Coincidence

## Coincidence

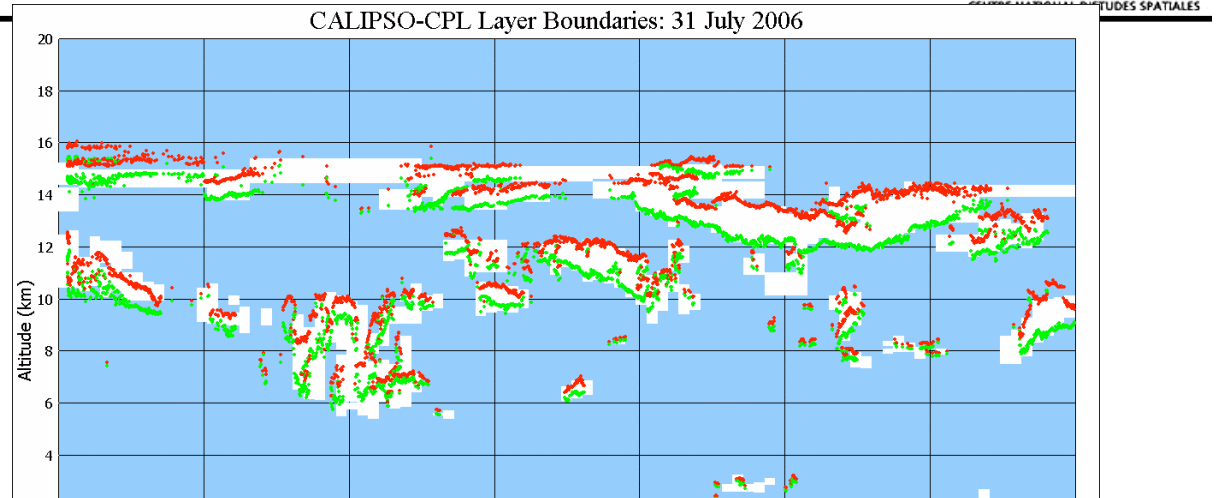




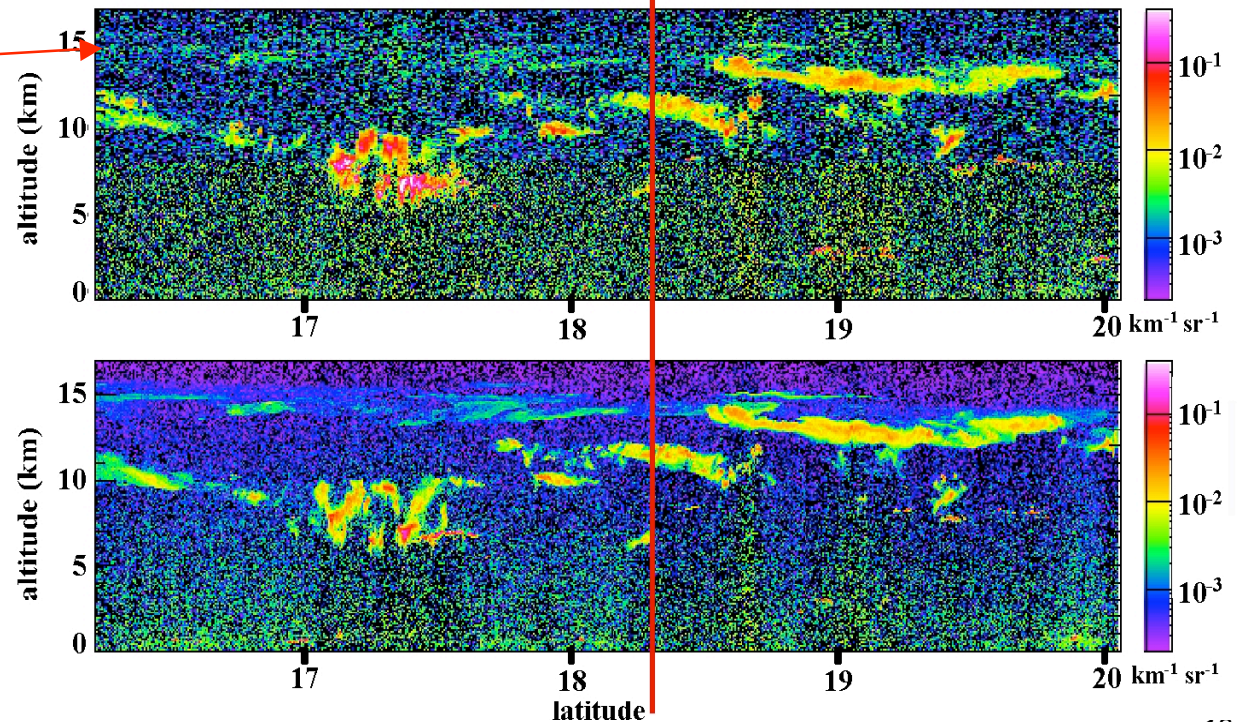
# Daytime CPL-CALIOP Comparison: 31 July



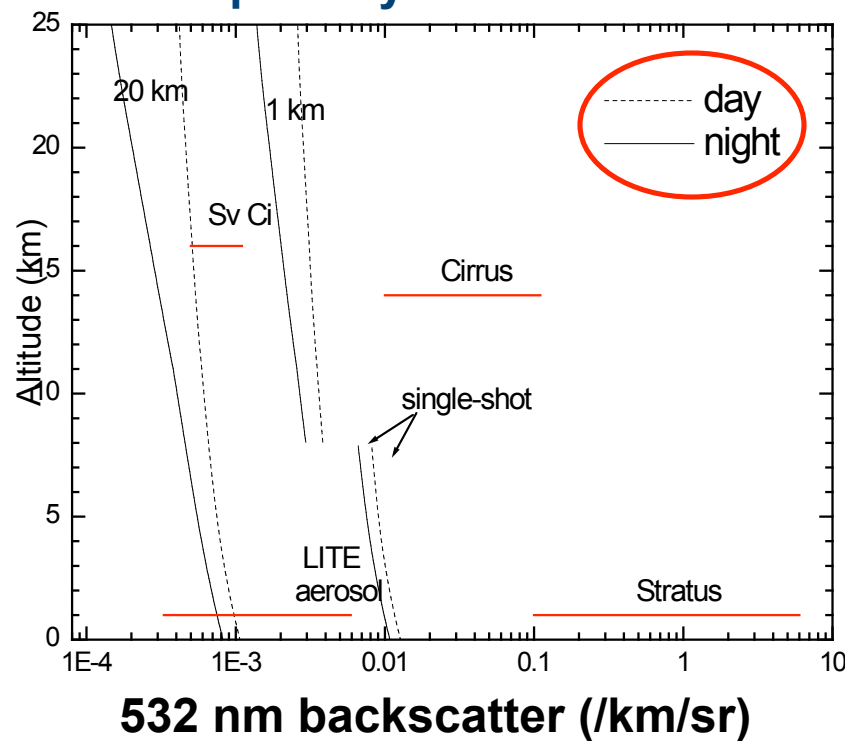
CALIPSO cloud boundaries shown in white.  
CPL cloud boundaries over-plotted in red (top) and green (bottom).



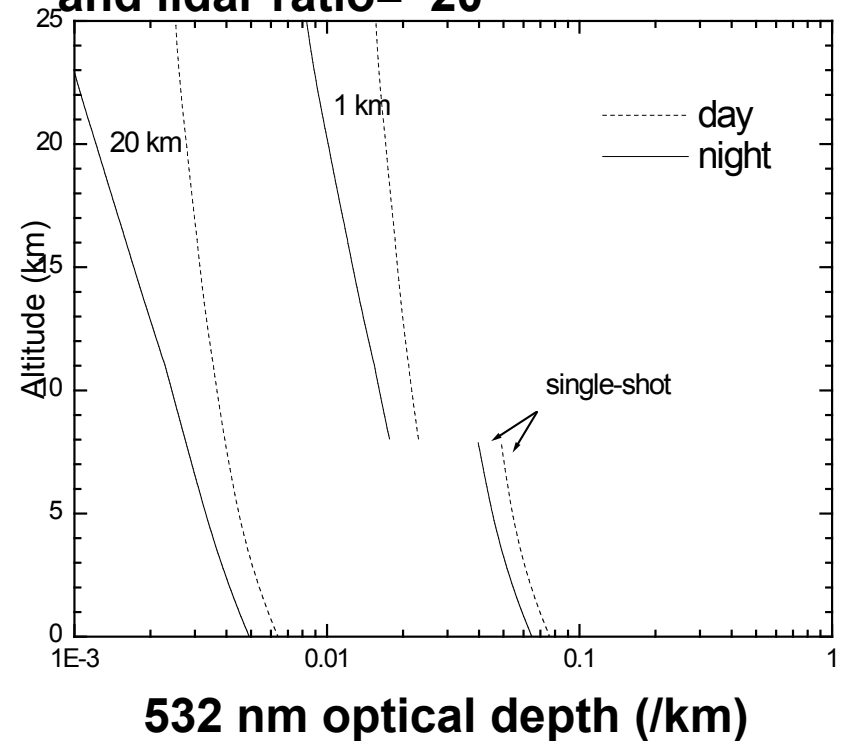
$\tau \sim 0.01$



**Day-night sensitivity differences are small, especially for low clouds**



**Assuming layer thickness = 300 m and lidar ratio = 20**



**Standard horizontal scales of data products: 1/3, 1, 5, 20, 80 km**

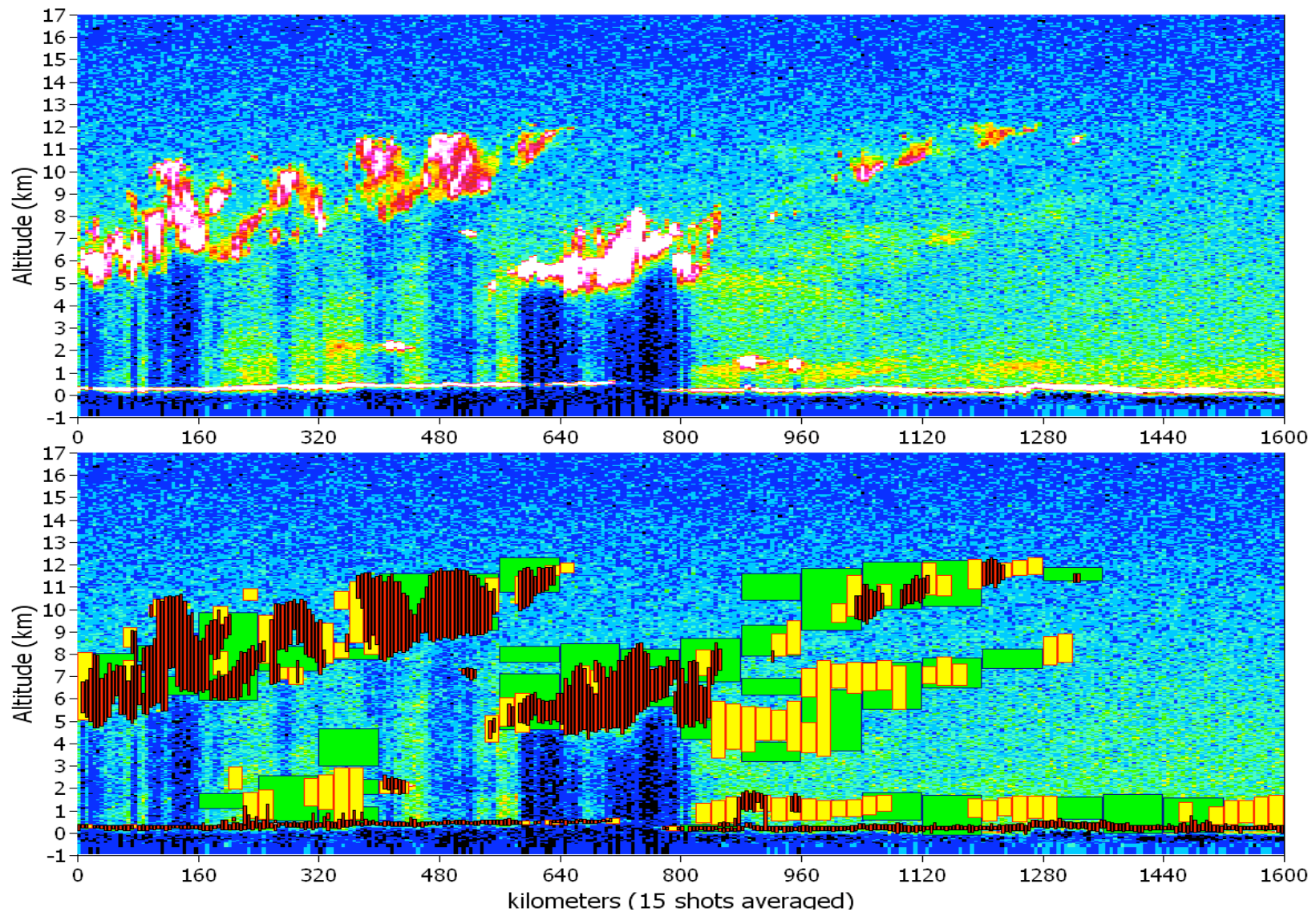




# Layer Detection Simulation



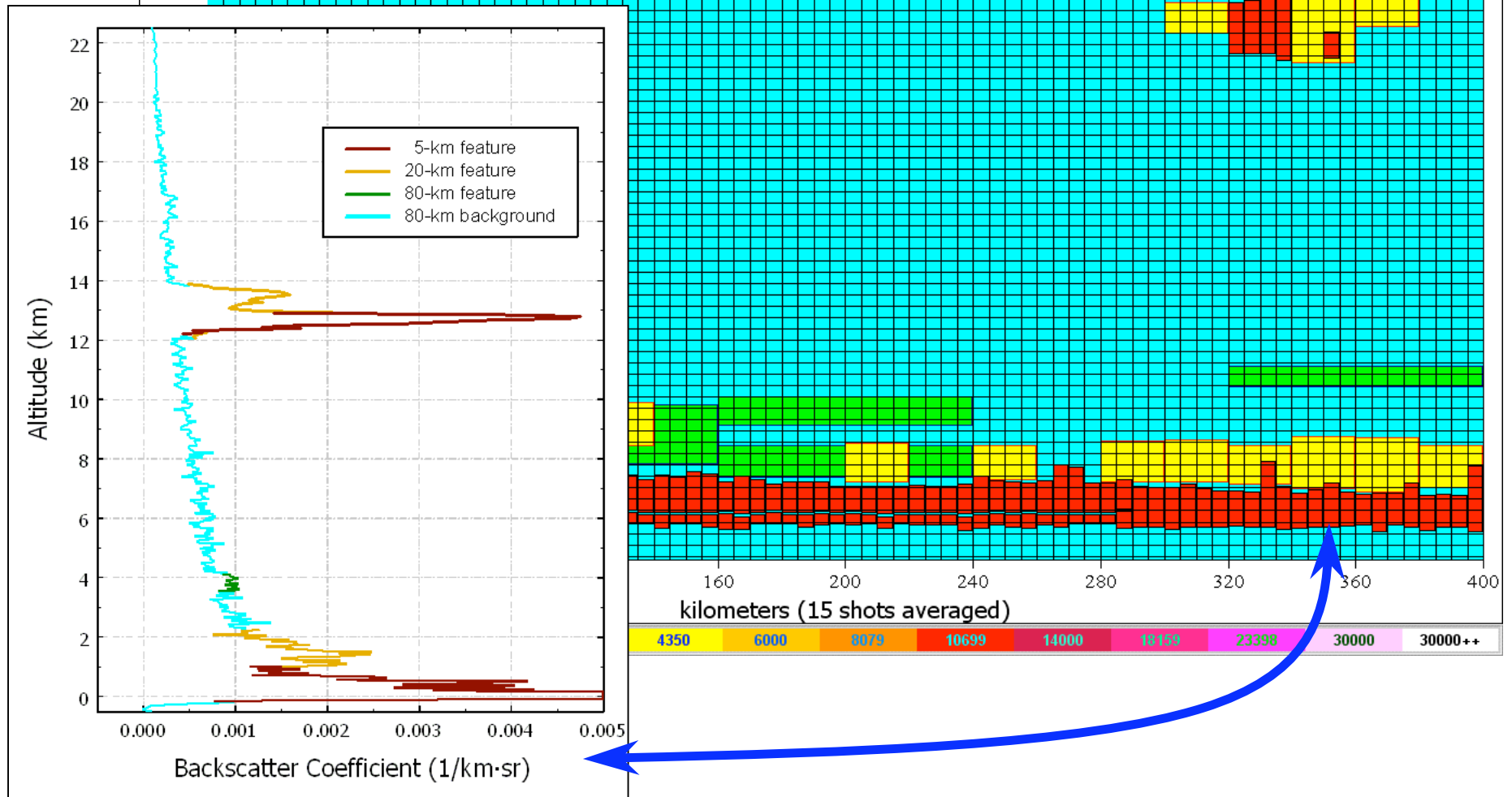
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L2A.2:

532nm Total Backscatter : LiteRev022SmallDemo.sim

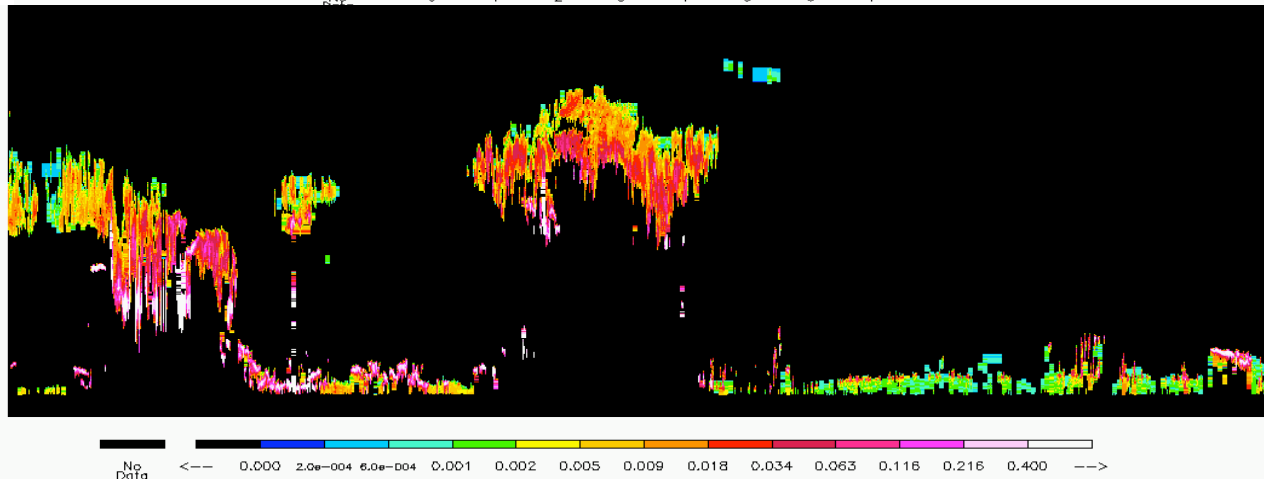
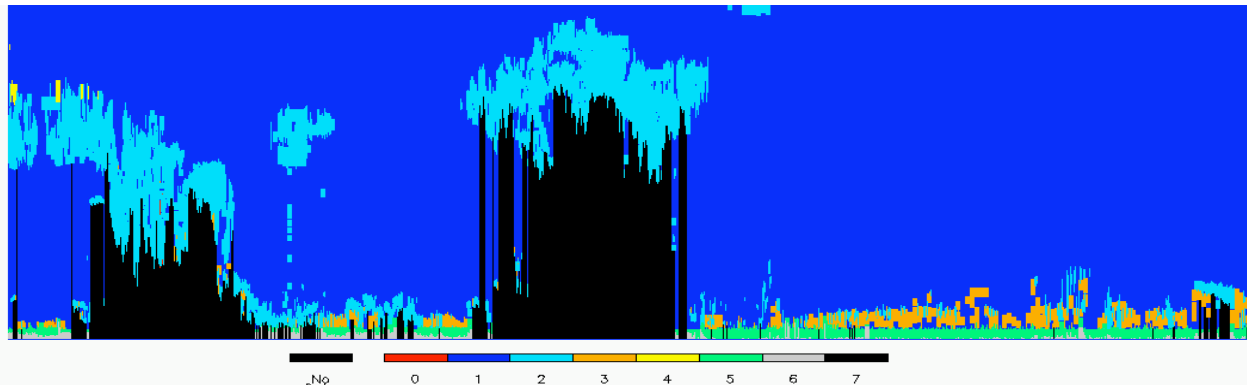
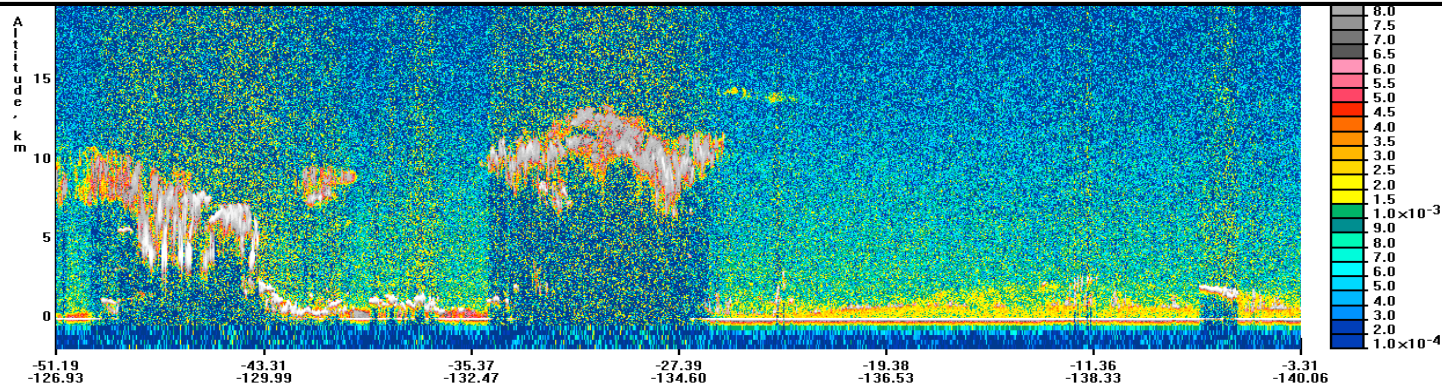




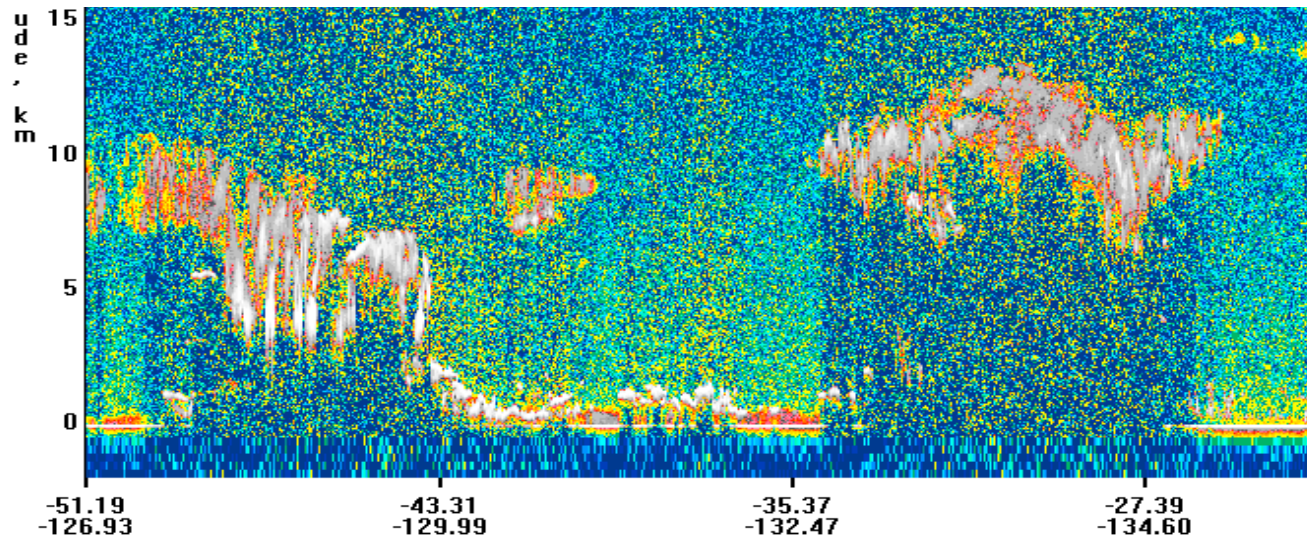
# First extinction retrieval results



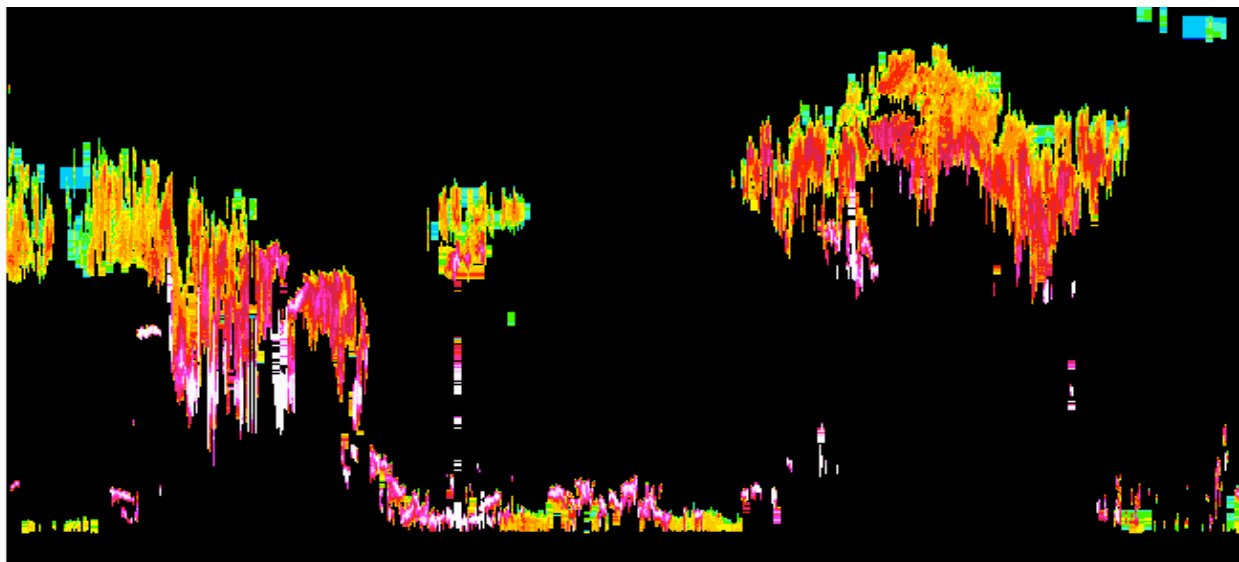
CENTRE NATIONAL D'ETUDES SPATIALES



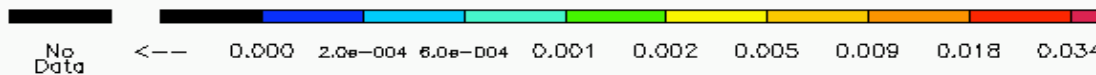
# Expanded view



**Level 1  
(532 nm)**



**Particulate  
Backscatter**





# Data Products: Plans



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- **Version 2 release: November 2007**
  - To include all CALIOP and IIR Level 2 products
  - Improved calibration
    - > New scheme for 532 night
    - > Improved 532 daytime scheme
  - Improved scene ID algorithms → better CAD
    - > will also improve aerosol typing, cloud I/W (not in prov. release)
  - **EXTINCTION PRODUCTS!**
    - > Preparing to move from debugging to validation
  - **POST-EXTINCTION PRODUCTS!!**
    - > Particle depolarization, color ratio, cloud IWC, etc.



# Data Integration Activities Underway



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- **Merged CP/CS GeoProf product (Jay Mace/UU-SLC)**
  - Objective: merged CP-CS cloud mask
  - Status: a few initial granules processed
- **NEWS (Seiji Kato/LaRC)**
  - Objective: produce merged CP/CS/MODIS/CERES along CP/CS groundtrack
  - Status: initial CP/CS/MODIS examples
- **A-train Data Depot (Steve Kempner/GSFC)**
  - Objective: develop capability (based on GIOVANI) to visualize and explore co-registered data from Calipso, Cloudsat, CERES, MODIS, AIRS, MLS (and others)
  - Status: developing tools

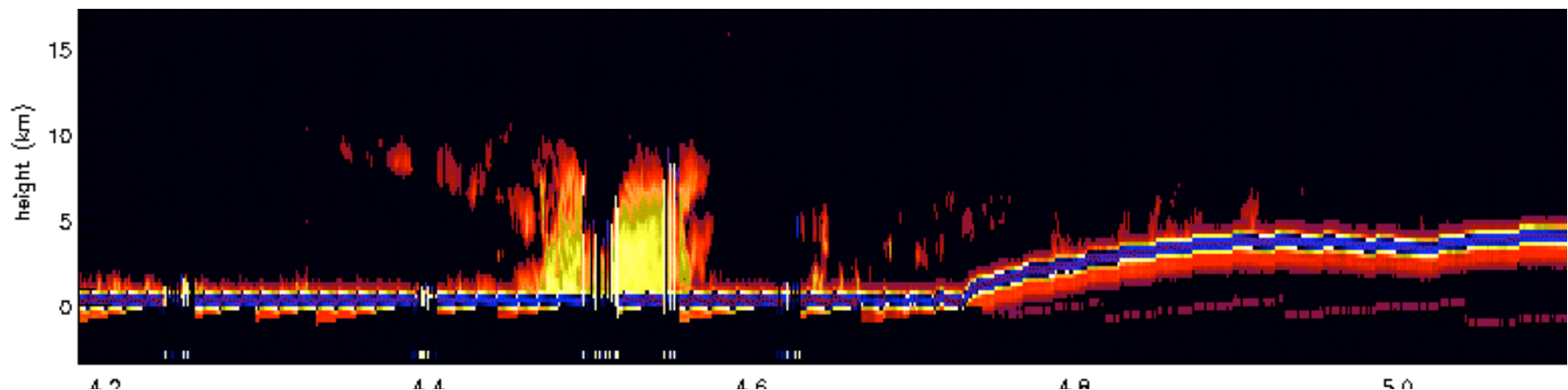
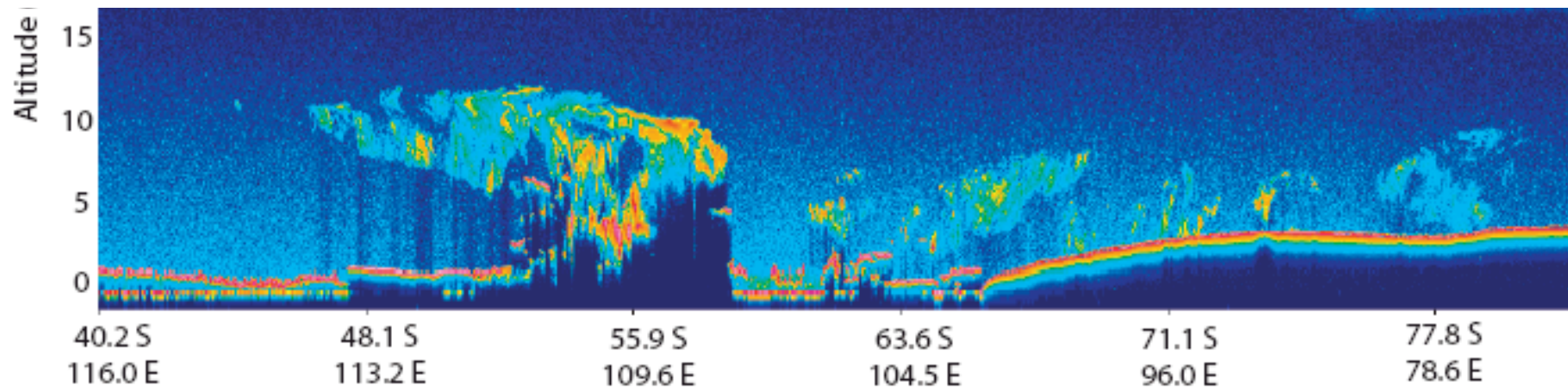
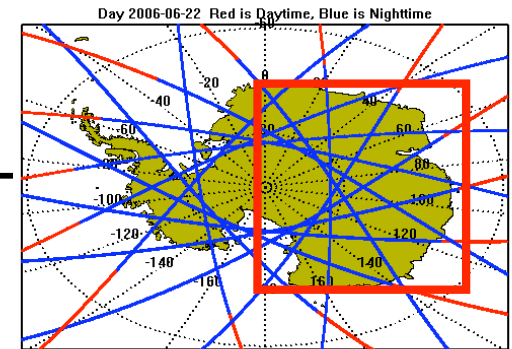




# CALIPSO and CloudSat

CALIPSO has observed thin cirrus, marine stratus missed by CloudSat

CloudSat penetrates deep convective cloud





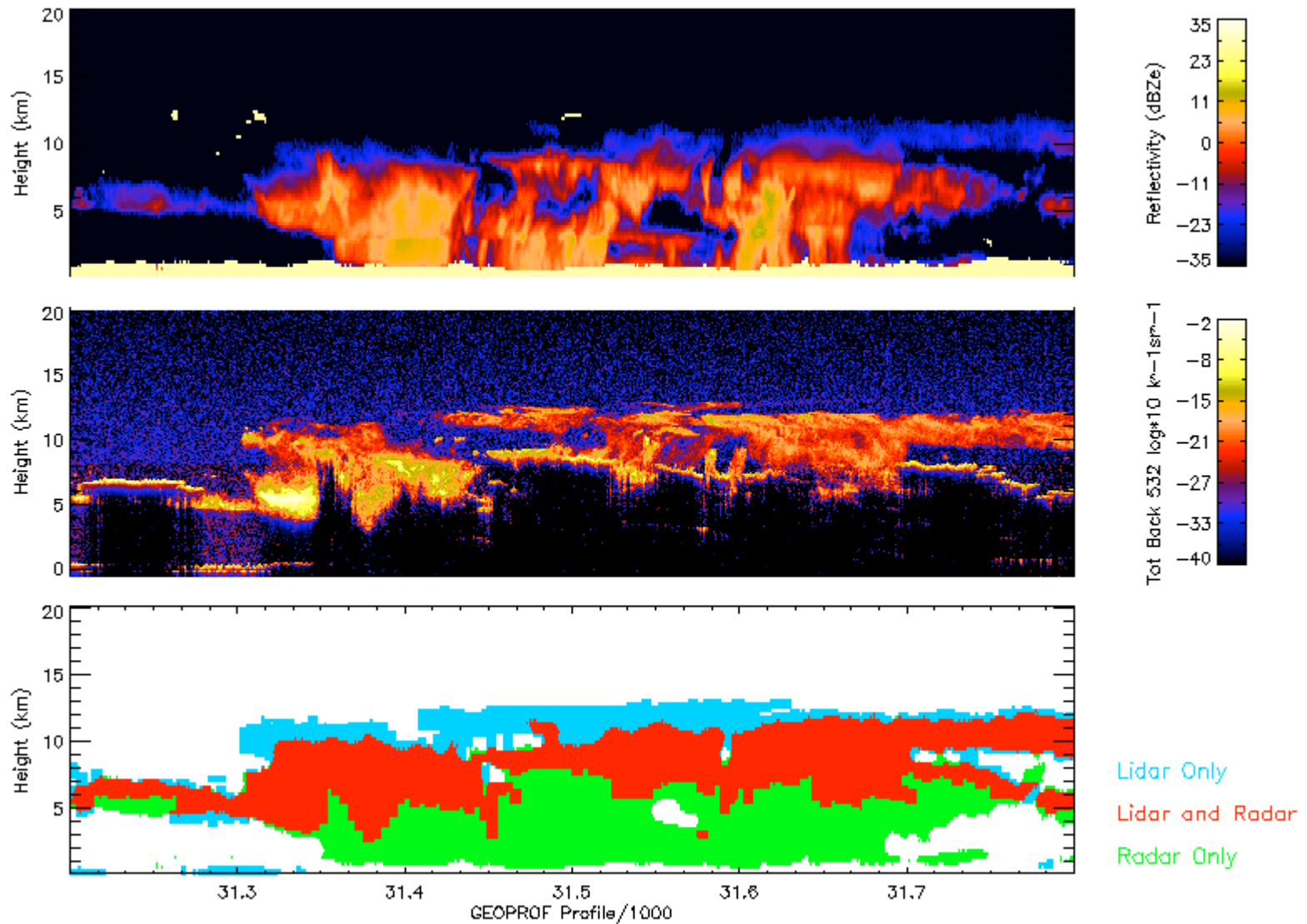
# Merged CALIPSO-CloudSat GEOPROF Product (Jay Mace)

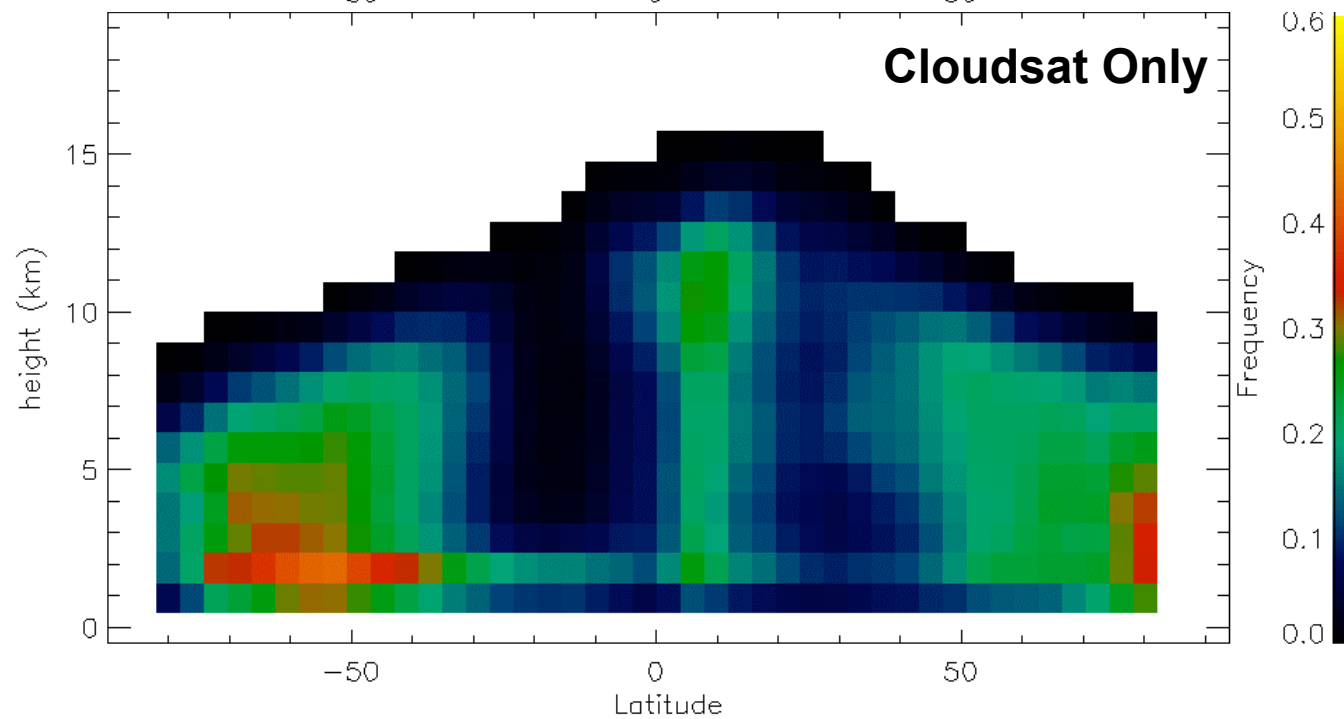
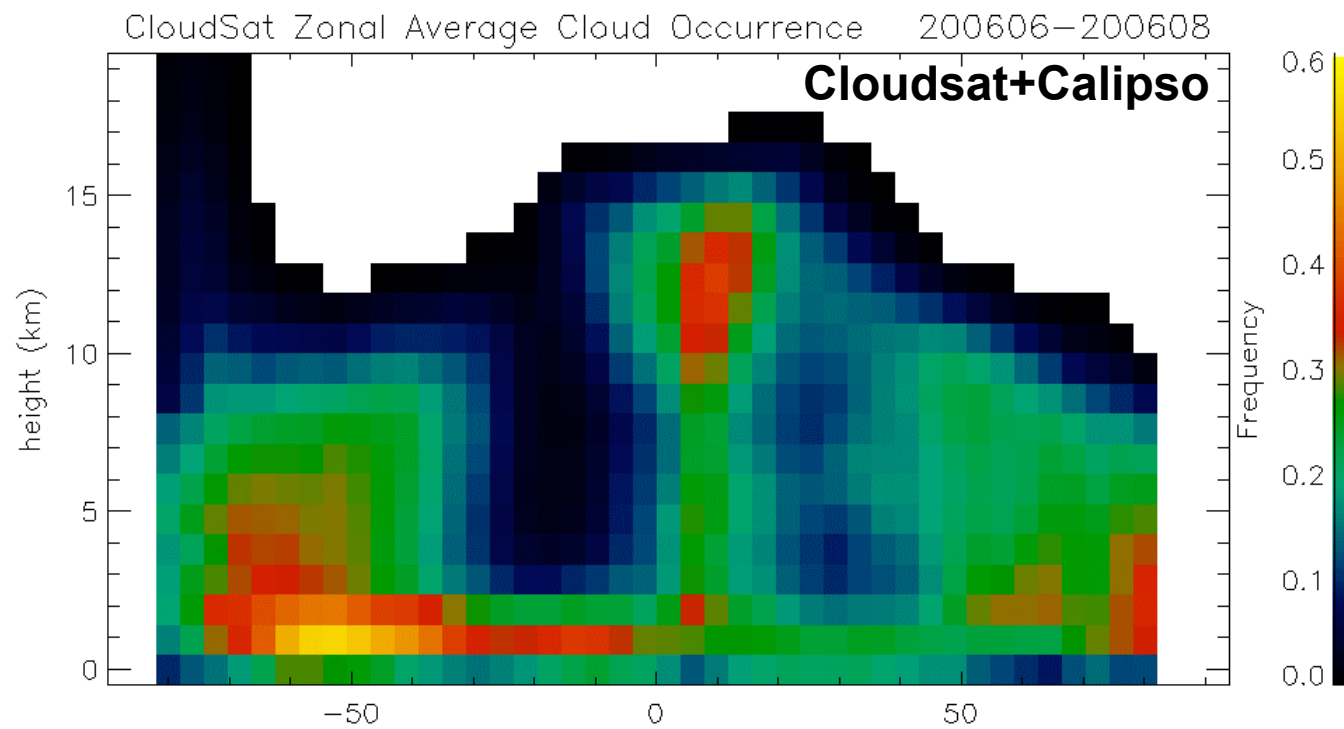


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GEOPROF / LIDAR Comparisons

2006288035706\_02473\_CS\_2B-GEOPROF\_GRANULE\_P\_R03\_E02

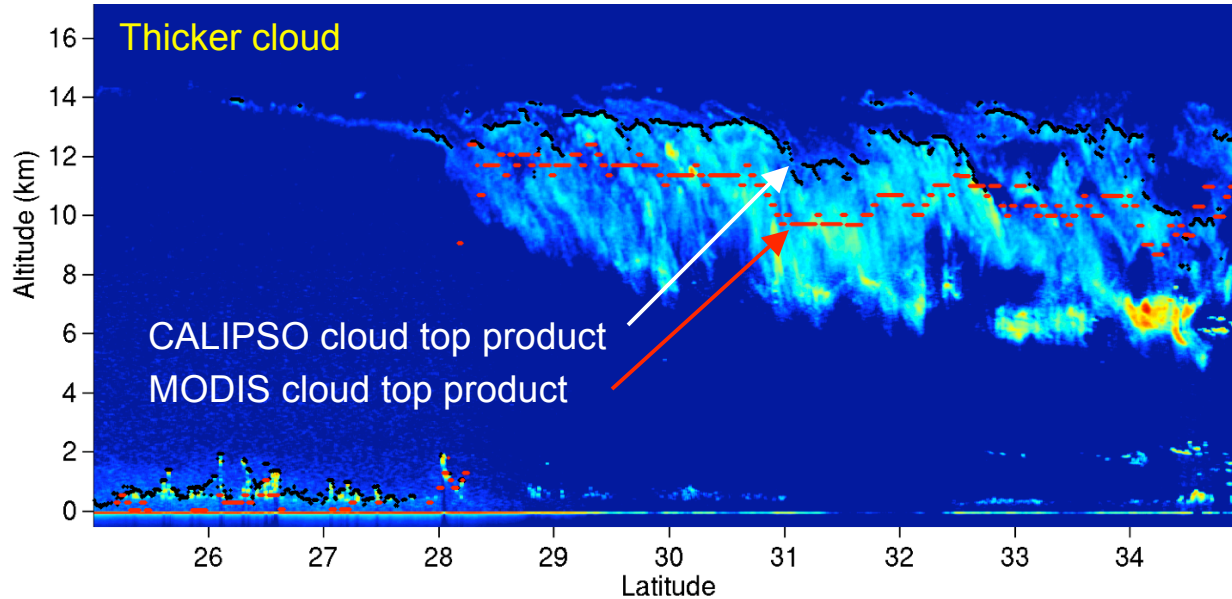




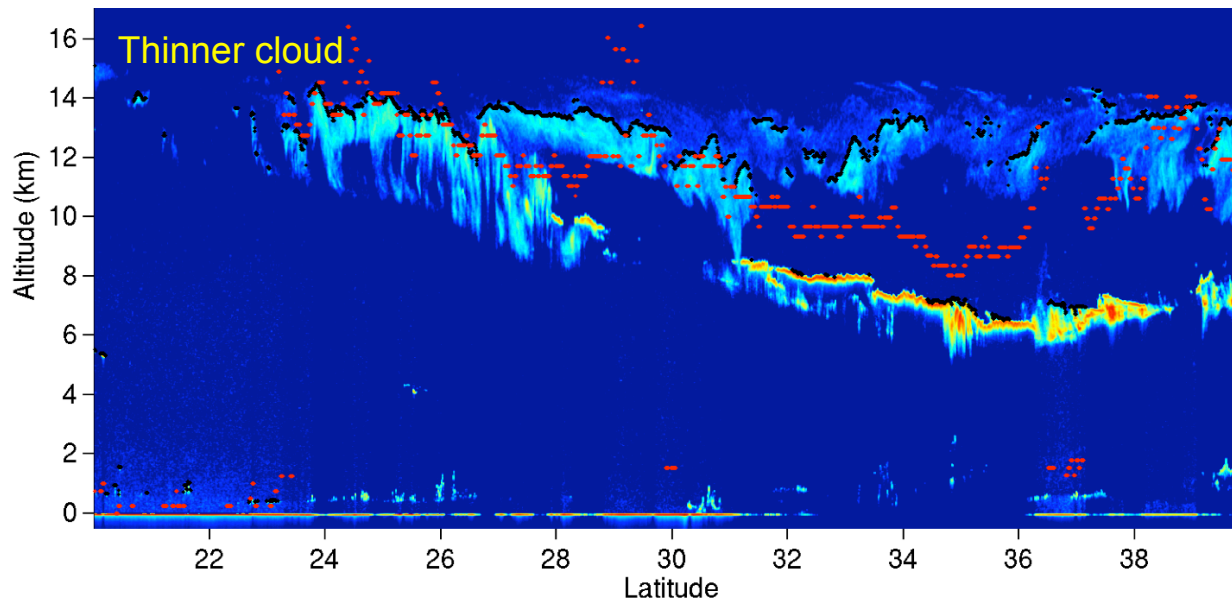
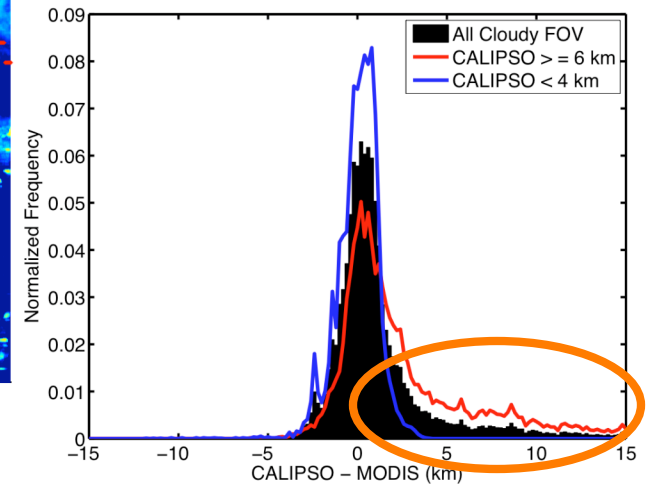
(courtesy  
Jay Mace)



# Cloud Top Comparisons CALIPSO vs. MODIS (June 15, 2006)



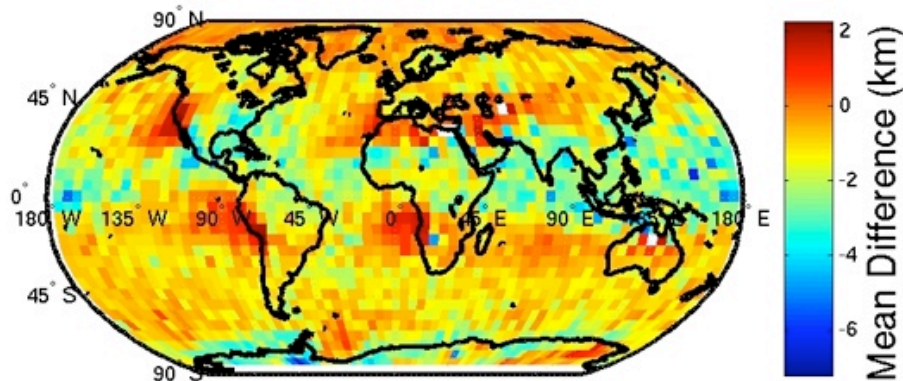
**Distribution of CALIPSO-MODIS  
cloud height difference**



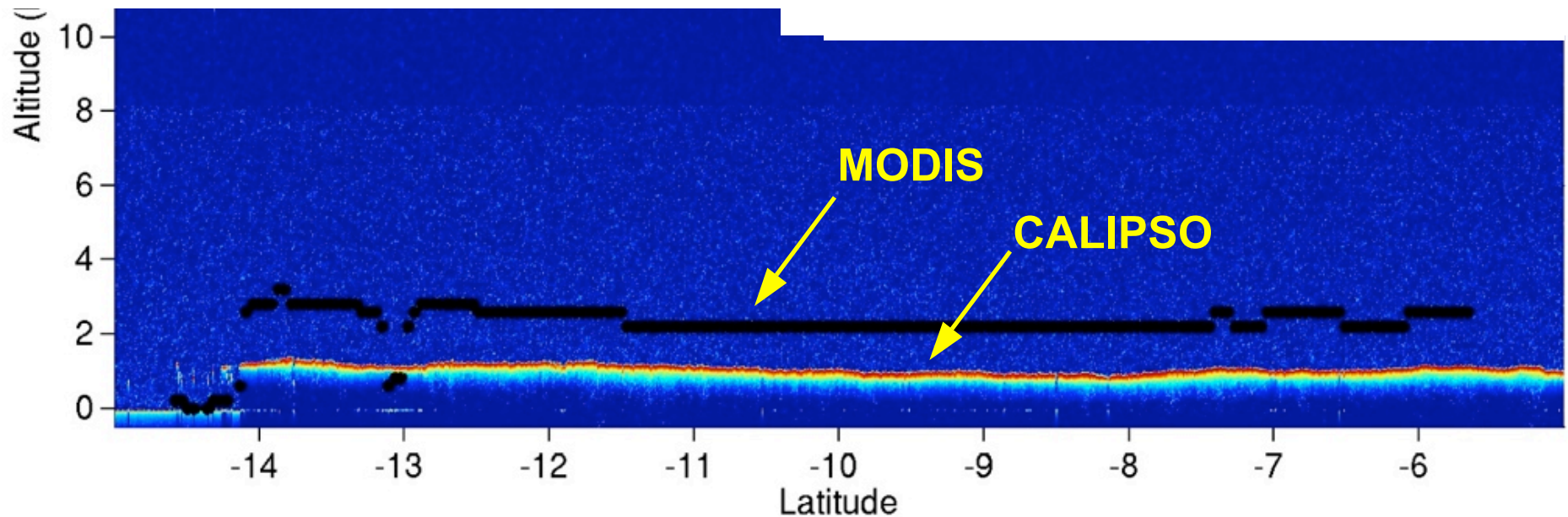
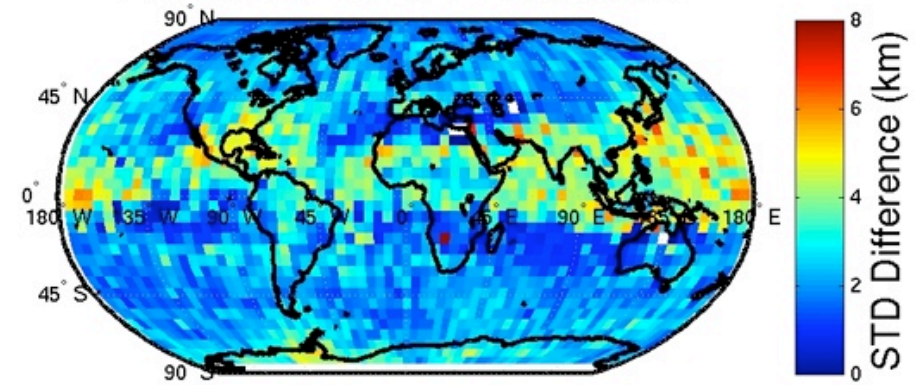
(courtesy Bob Holz  
and Steve Ackerman)

MODIS cloud height, for  
thin clouds, is sensitive  
to layers below the cloud

Mean MODIS-CALIPSO Differences



STD MODIS-CALIPSO Differences





# Upcoming Near-Term Decisions



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- **CALIPSO REVEX: 27 June**
  - Annual CNES review of satellite missions
- **Two 'science' issues to address**
  - Precession across MODIS swath during third year of mission
  - Change of nominal satellite attitude from current  $0.3^\circ$



# Precession



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- **Original plan (1998) was to precess from east to west across the MODIS swath over the 3-year mission**
  - Purpose was for CALIPSO to sample all MODIS view angles during all seasons and over all climatic regimes
- **After selection of CALIPSO and CloudSat, the plan was changed to fly “in-line” with MODIS during the two year CloudSat mission and then precess across the MODIS swath during year 3**
- **Meanwhile, the A-train happened**
- **Time to re-evaluate**
  - Initial discussions indicate the current preference is to stay in place and not precess
  - Before finalizing this decision
    - > must address technical concerns (power/thermal impacts)
    - > need to solicit science team recommendations



# Upcoming decisions: nominal attitude

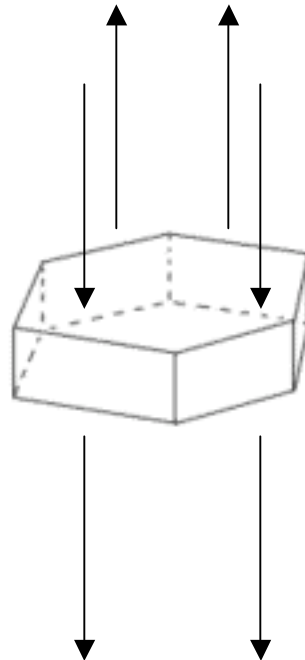


CENTRE NATIONAL D'ETUDES SPATIALES

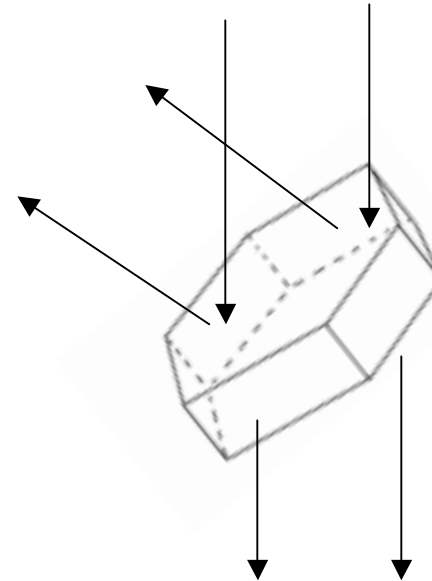
- **Nominal pointing:  $0.3^\circ$  off-nadir**
  - to avoid specular reflections from still water (swamps, ponds, rivers, etc)
  - but get specular reflections from horizontally oriented ice crystals (originally seen as a benefit: information)
- **Collected data at  $3^\circ$  off-nadir in November 2006**
- **Primary issue: specular returns from oriented ice crystals**
- **Recommendation: change nominal attitude to  $\sim 3^\circ$**
- **Impacts:**
  - **Simplifies algorithms**
  - ❖ **Improves cloud optical depth retrievals**
  - **Introduces a discontinuity into the dataset**
  - **No longer can identify oriented ice particles**
  - **Transmission decreases, may not penetrate to cloud base as often**



# Horizontal geometry is 'special'

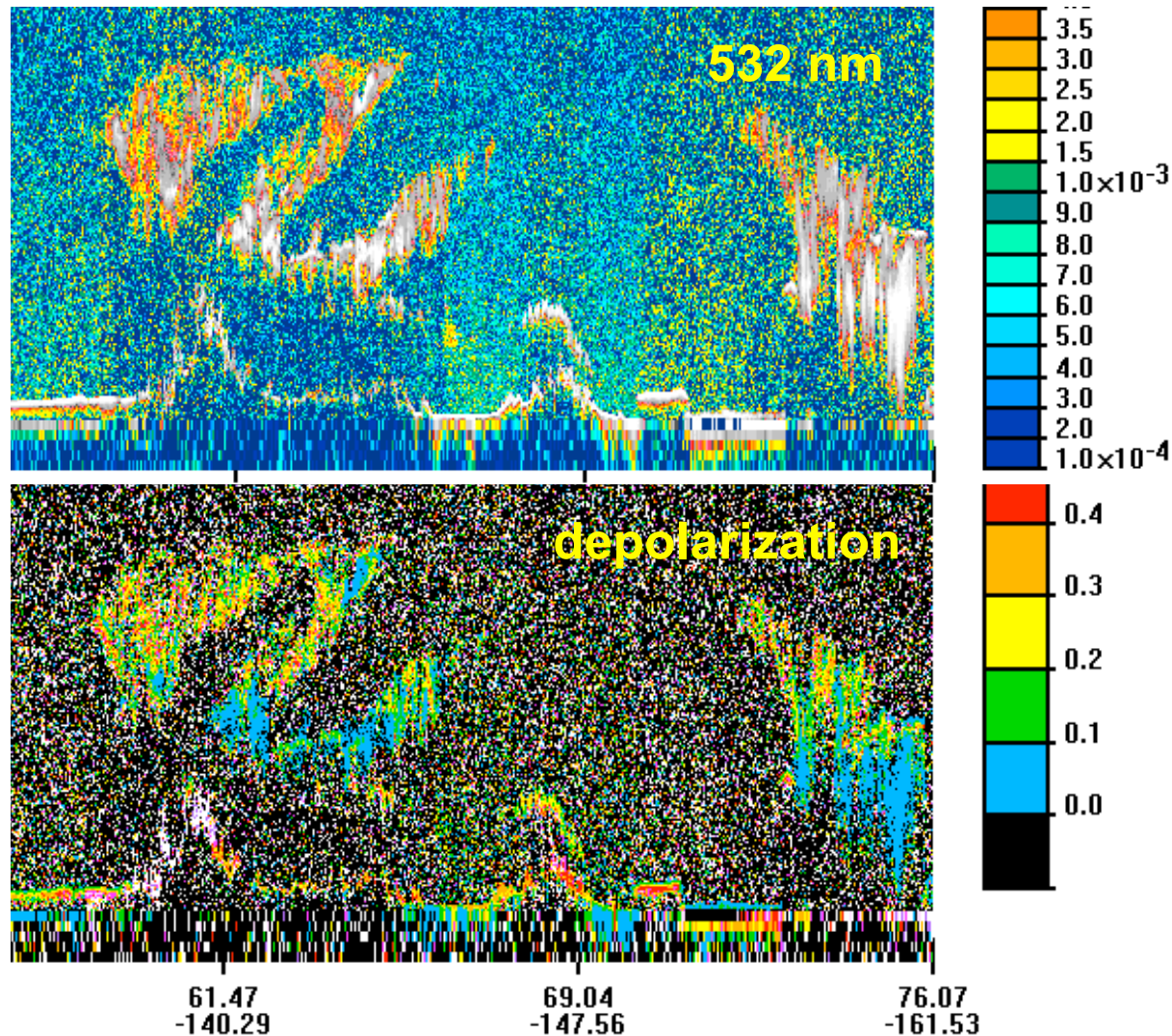


Lidar ratio:  $\sigma/\beta \rightarrow 1 \text{ sr}$



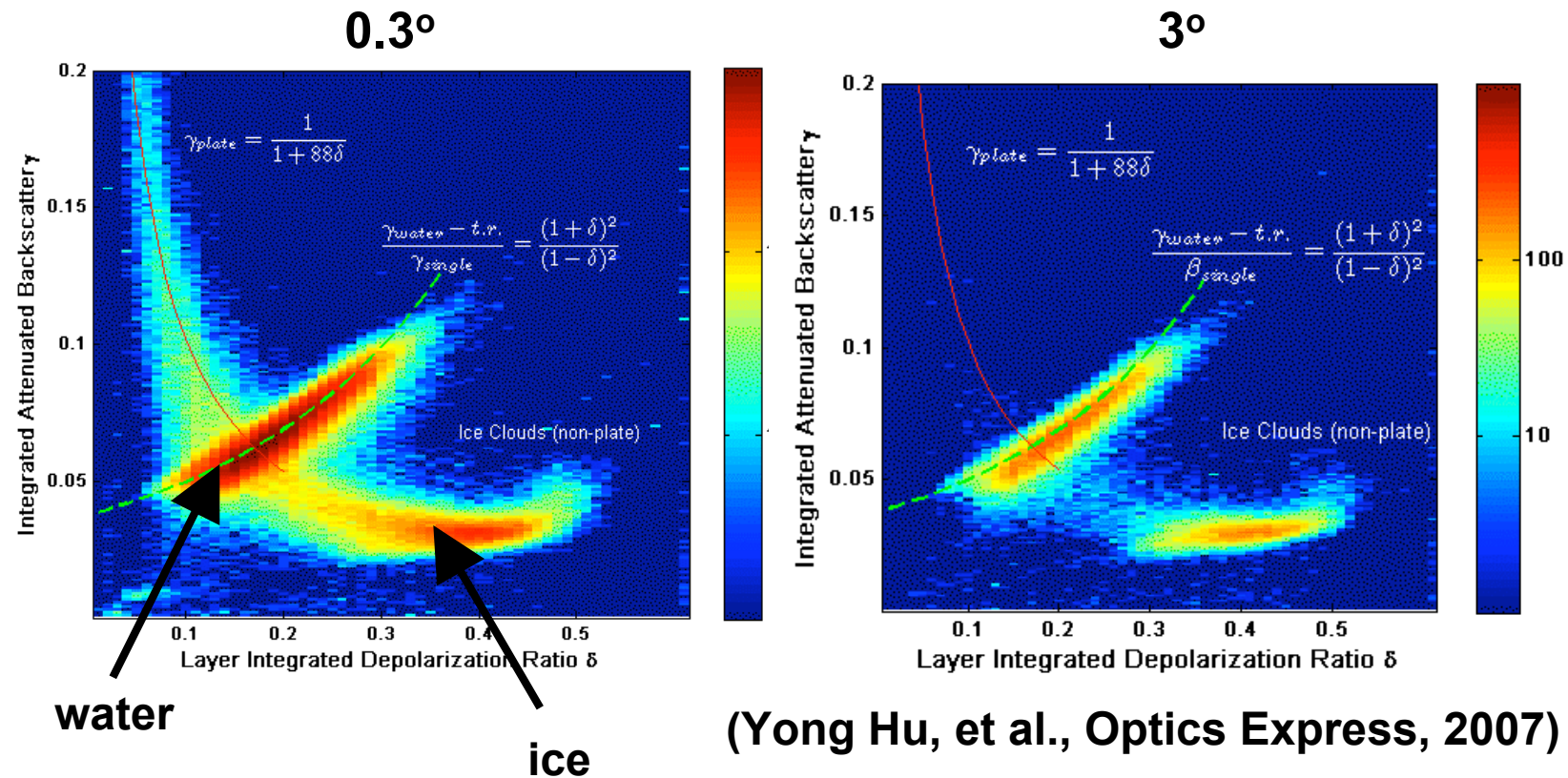
$\sigma/\beta \sim 25 \text{ sr}$

# Oriented Crystals (Arctic data)



Oriented crystals identified from: strong backscatter, low attenuation (implying small lidar ratio) and low depolarization

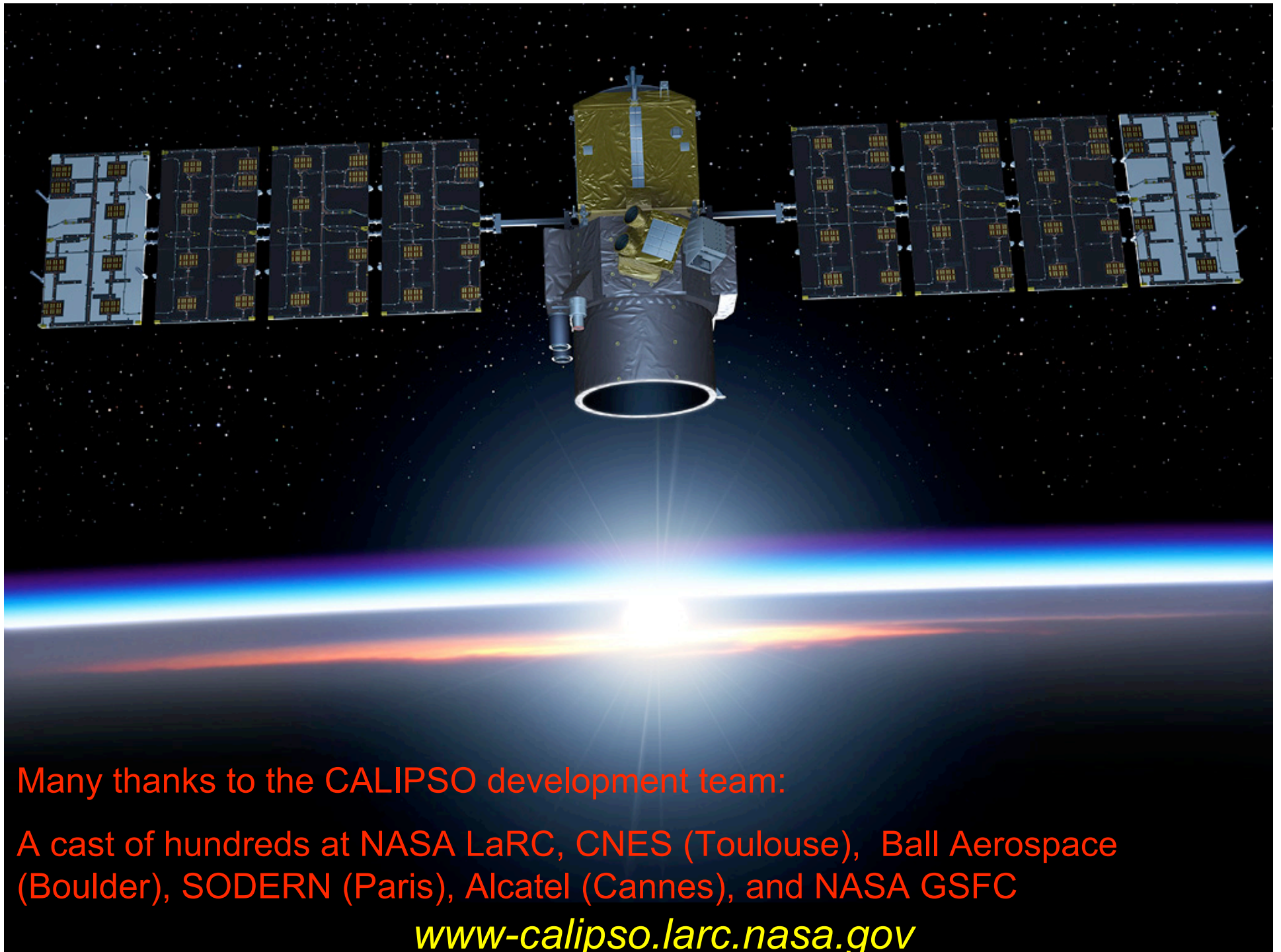
# Comparison of 0.3° and 3° cloud data



Layer-integrated  
attenuated backscatter

Layer-integrated  
depolarization





Many thanks to the CALIPSO development team:

A cast of hundreds at NASA LaRC, CNES (Toulouse), Ball Aerospace (Boulder), SODERN (Paris), Alcatel (Cannes), and NASA GSFC

[www-calipso.larc.nasa.gov](http://www-calipso.larc.nasa.gov)